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# **NAVAL POSTGRADUATE SCHOOL**

**MONTEREY, CALIFORNIA**

## **THESIS**

**A SYSTEMS ENGINEERING APPROACH TO ADDRESS  
HUMAN CAPITAL MANAGEMENT ISSUES IN THE  
SHIPBUILDING INDUSTRY**

by

Hal M. Todd  
Douglas S. Parten

September 2008

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**A SYSTEMS ENGINEERING APPROACH TO ADDRESS HUMAN CAPITAL  
MANAGEMENT ISSUES IN THE SHIPBUILDING INDUSTRY**

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## **ABSTRACT**

Recent human capital trends within the Department of Defense (DoD) and its contractors have shown a dramatic decrease in science and engineering skill levels due to retirement and attrition. This has caused major concern for leaders, especially regarding engineering talent necessary for shipbuilding. This study investigated current DoD Human Capital Management (HCM) strategies for attracting, developing, retaining and managing competencies and intellectual resources for science and engineering talent within the shipbuilding industry. The investigation consisted of a survey of current DoD and industry HCM frameworks, an analysis of the needs of key stakeholders, and an examination of the gaps in the HCM strategies employed by these stakeholders. The result of the analysis was the development, via a functional analysis, of a notional HCM architecture for the shipbuilding industry that addresses stakeholder needs and closes the perceived gaps in current strategies. The notional HCM architecture was developed to provide a first iteration of a HCM architecture tailorable to a particular stakeholder's HCM needs. This study also developed a notional overall measure of effectiveness (OMOE) model to suggest the means by which stakeholders can judge the effectiveness of their tailored version of the HCM architecture. This first-iterate OMOE was derived using weights and metrics based on the author's insights gained from the research performed during this study, and suggests that further refinement of the HCM architecture is required.



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## LIST OF ACRONYMS AND ABBREVIATIONS

ABS	American Bureau of Shipping
AHP	Analytic Hierarchy Process
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASNE	American Society of Naval Engineers
CAD	Computer Aided Design, Computer Aided Drafting
CIPS	Center for Innovation in Public Service
CMM	Capability-Maturity Model
CNO	Chief of Naval Operations
CVN	Multi-Purpose Aircraft Carrier (Nuclear Propulsion)
DAU	Defense Acquisition University
DD	Destroyer
DDG	Guided Missile Destroyer
DoD	Department of Defense
DoN	Department of the Navy
ESDRC	Environment and Sustainable Development Research Center
ESO	Electric Ship Office
FA	Functional Analysis
FFBD	Functional Flow Block Diagram
GAO	Government Accountability Office (United States)
GWOT	Global War on Terror
HCM	Human Capital Management
HOQ	House of Quality
HR	Human Resources
IEC	International Engineering Consortium
IEEE	International Institute of Electrical and Electronics Engineers

IPS	Integrated Power System
INCOSE	International Council on Systems Engineering
ISO	International Organization for Standardization
KSA	Knowledge, Skills, and Abilities
LPD	Amphibious Transport Ship Dock
MIT	Massachusetts Institute of Technology
MMO	Massively Multiplayer Online
MOE	Measure of Effectiveness
MOP	Measure of Performance
NASSCO	National Steel and Shipbuilding Company
NAVAIR	Naval Air Systems Command
NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NA&ME	Naval Architecture & Marine Engineering
NC-EQW	National Center on Educational Quality of the Workforce
NNR-NE	National Naval Responsibility for Naval Engineering
NPS	Naval Postgraduate School
NCW	Net-Centric Warfare
NSPS	National Security Personnel System
NSRP-ASE	National Shipbuilding Research Program Advanced Shipbuilding Enterprise
OMOE	Overall Measure of Effectiveness
ONR	Office of Naval Research
OSD	Office of the Secretary of Defense
OUSD -AT&L	Office of the Under Secretary of Defense for Acquisition, Technology & Logistics
PEO	Program Executive Office
PMS	Program Management, Ship
QFD	Quality Function Deployment
R&D	Research & Development

SEI	Software Engineering Institute, Carnegie-Mellon University
SLBM	Submarine-Launched Ballistic Missile
SME	Subject-Matter Expert
SNAME	Society of Naval Architects and Marine Engineers
SSN	Attack Submarine, Nuclear Powered
SSP	Strategic Systems Programs
SW-CMM	Software Capability-Maturity Model
USMC	United States Marine Corps
WAF	Worth Activation Function
WTF	Worth Transfer Function

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## **EXECUTIVE SUMMARY**

This thesis investigates human capital management (HCM) within the DoD shipbuilding industry and addresses the issue of decreasing science and engineering skill levels due to retirement and other attrition, a concern to both DoD and industry. An overview is provided of the characteristics of human capital and HCM principles, highlighting the importance effective HCM has on an organization's strategic position within the marketplace. Maturity-based frameworks are presented as examples of disciplined and continuous processes for developing and improving HCM practices in DoD and industry.

The authors perform a stakeholder analysis to determine the key stakeholders within government, industry, and academia that have an interest in HCM for the shipbuilding industry. In the analysis, 134 stakeholders are identified, classified, and prioritized, and their specific HCM needs are identified, leading to ten high-priority HCM requirements.

Next, the authors perform a gap analysis to identify and investigate the perceived gaps in the shipbuilding industry HCM strategies terms of the threats to the industry and its vulnerabilities. Gaps are highlighted indicating the difficulty the industry has in effectively attracting engineering talent, developing it, and transferring the critical skills learned to the next generation of engineers.

The stakeholder and gap analysis results are used to guide the development of a top-level notional HCM functional architecture to meet the industry's HCM needs. The architecture is presented as a notional framework that can be tailored according to particular stakeholder HCM priorities. A notional overall measure of effectiveness (OMOE) model is presented to illustrate to stakeholders how the effectiveness of the tailored architecture may be assessed. This first-iterate OMOE was derived using weights and metrics based on the author's insights gained from the research performed during this study, and suggests that further refinement of the HCM architecture is required.



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Doug Parten:

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## **I. INTRODUCTION**

### **A. DEPARTMENT OF DEFENSE AND SHIPBUILDING INDUSTRY HUMAN CAPITAL TRENDS**

Engineering and technical skill levels in the United States have been a major concern facing the Department of Defense (DoD) and its contractors for the past decade. The national defense needs of the Cold War utilized much of the available professional engineering talent in the United States. With the end of the Cold War, a decline in the number of engineers and scientists working DoD programs has occurred as opportunities in civilian industry have become more inviting. In addition, work on DoD programs, once desirable, has been overshadowed by the allure and excitement of careers working on new technologies, such as computer and internet systems, quantum computing, and nanotechnology. As a result, fewer numbers of engineers are entering the defense industry, causing the average age of the work force to increase. Thus, the core knowledge and experience base is nearing retirement in ever greater numbers, elevating the risk that the critical technical skills and systems knowledge required to develop future military systems will be lost (Office of the Undersecretary of Defense for Acquisition, Technology, and Logistics [OUSD AT&L], 2006).

#### **1. Navy Human Capital Management Perspective**

Each area of DoD faces Human Capital issues, but approaches these issues from different perspectives. According to the Office of the Undersecretary of Defense for Acquisition, Technology, and Logistics (OUSD AT&L) *Report of the Defense Science Board Task Force on Future Strategic Strike Skills* (2006), the U.S. Navy, as part of its Human Capital Management Plan, has emphasized the importance of retaining personnel having strategic technical skills. The plan is particularly effective at utilizing the talent made available from officer personnel

that remain in the strategic strike field by transferring to related civilian positions after leaving active duty. The study further states that this is unique among the strategic arms of the of the U.S. military establishment:

The Navy's Strategic Systems Programs (SSP) is the only DoD strategic strike organization to specifically label [sic] their effort a "Human Capital Management Plan." It recognizes the aging of its current workforce and acknowledges that the lack of new development and production programs is a disincentive for the recruitment and retention of a skilled workforce (p. 49)

The SSP does not limit this mandate to DoD activities, and urges the industry to support the Navy's effort by developing their own plans for development and management of their human capital (OUSD AT&L, 2006).

## **2. Shipbuilding Industry Concerns**

Within the shipbuilding industry, leaders are gaining awareness of how human capital issues will affect the future of the industry. In recent testimony before Congress, Michael Toner, Executive Vice President Marine Systems, General Dynamics stated (2005), "The strength of the industry lies in our people, and the engineering, production, and ship technology that they bring to bear in delivering these warships" (p. 1). In his testimony, he expressed his concerns regarding the experience level of the engineering and design work force at General Dynamics' Electric Boat Division. Toner cited estimates that 2,200 experienced engineers and designers are required to design new submarines efficiently. For the last 40 years, this workforce has maintained at least 2,500 personnel. However, the Navy's current plans for submarine research and development (R&D) and design development have significantly reduced the number of new submarine designs. According to Toner:

The current forecast for submarine R&D and new design development places the Electric boat engineering and design workforce at risk. For the first time since the start of the nuclear submarine program, over 50 years ago, there is no new submarine design planned” (p. 12).

This trend puts the shipbuilding engineering experience base at great risk as the opportunities for work diminish.

The Government Accountability Office (GAO) has noted recent increases in shipbuilding costs. In its 2005 report *Improved Management Practices Could Help Minimize Cost Growth in Navy Shipbuilding Programs*, the GAO examined eight shipbuilding programs (DDG 91 & 92, CVN 76 & 77, LPD 17 & 18 and SSN 774 & 775). According to the report, these programs have exhibited cost growth in aggregate of \$2.1 billion. GAO noted that 77 percent of this growth was due to increases in material and labor costs, and estimates that these costs could increase further to \$3.1 billion if the constructing shipyards do not maintain their efficiency and meet schedule commitments (United States Government Accountability Office [GAO], 2005).

The same GAO report states that the increased ship acquisition costs resulted from the high proportion of inexperienced or “green” labor. Labor hour increases associated with the cost growth ranged from 33 percent to 105 percent, totaling 34 million extra labor hours expended in the construction of the eight ships. The reason for this increase, according to the shipyards, was the loss of a large number of experienced and skilled shipyard workers, who took higher paying jobs in other industries. This movement of human capital out of the industry puts a burden on the less experienced workers that remain to finish the job, which takes longer, and results in a significant amount of rework to correct mistakes caused by lack of experience (GAO, 2005).

## B. RECRUITING AND ATTRITION CONCERNS

As noted above, recent trends have shown a dramatic increase in the amount of science and engineering expertise leaving DoD due to retirement and attrition. As seen in Figure 1, taken from *The Civil Service Workforce After Strategic Sourcing*, the number of DoD science and engineering employees decreased greatly in the period 1990 to 1998 (DiTrapani, Adedeeji, & Lawler, 2000). Accompanying this reduction was a decrease in new talent entering engineering and science occupations. Current studies have identified a decline in qualified applicants due to diminishing enrollment in technical curriculums at colleges and universities (Figure 2). Stiff competition for the existing technical job pool from industries outside of shipbuilding further reduces the availability of applicants.

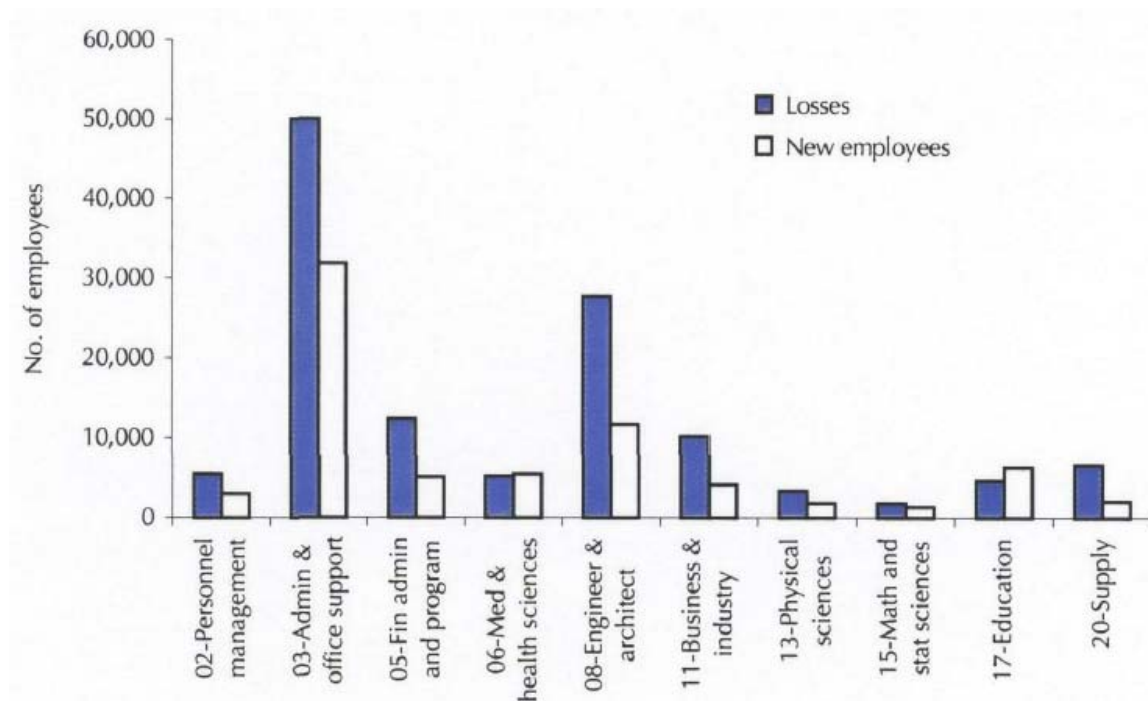


Figure 1. DoD Top Ten Occupations, Losses vs. New Employees, 1990-1998  
(From DiTrapani, Adedeeji, & Lawler, 2000)

U.S. Engineering Personnel				
University Graduates* (in thousands)				
	1980	1990	1995	2002
B.S.	68.8	81.3	78.1	73.6
M.S.	16.2	24.8	29.7	26.9
Doctorate	2.5	4.98	6.1	5.2

\* Statistical Abstract 2005

Figure 2. U.S. Engineering University Graduates (From Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics [OUSD AT&L], 2006)

Furthermore, security changes in marketplace dynamics due to 9/11 and the Global War on Terrorism (GWOT) have introduced increased eligibility restrictions within DoD and shipbuilding programs, thereby escalating limitations on candidate selection (OUSD AT&L, 2006). As shown in Figure 3, most graduate students in U.S. colleges and universities are foreign nationals.

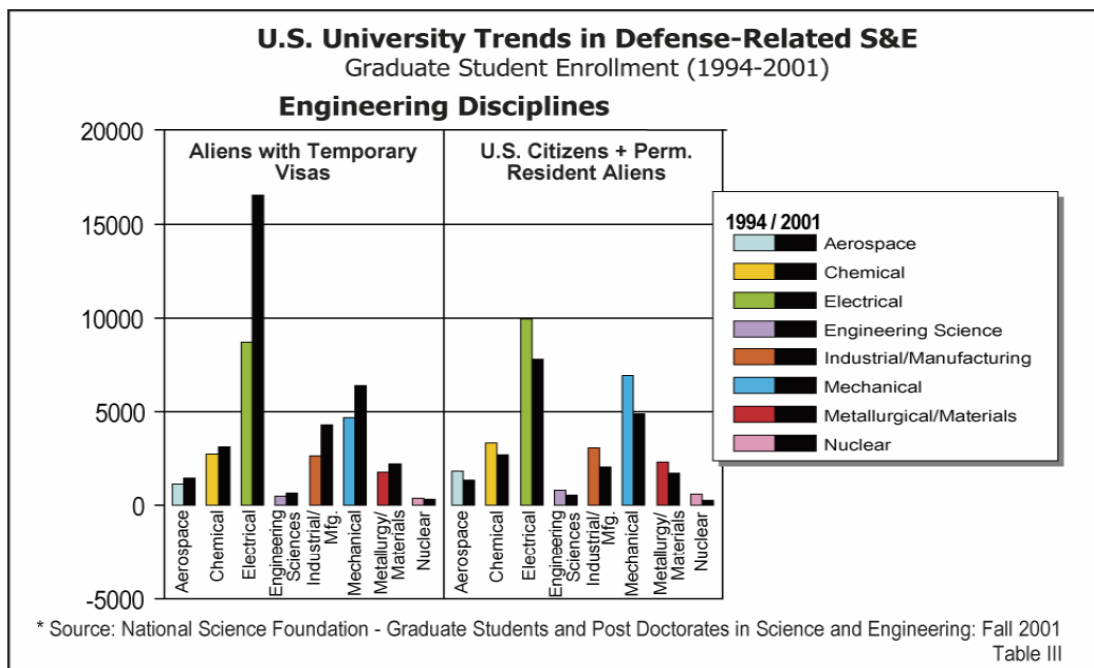


Figure 3. U.S. University Trends in Defense-Related Science and Engineering (From OUSD AT&L, 2006)



To compound the problem, the DoD civilian workforce has undergone significant change since the end of the Cold War, as noted in the GAO's report *DoD Civilian Workforce Planning* from 2004. This report cites a 38 percent reduction in civilian personnel in the period 1998 to 2002, directly related to post Cold War downsizing, base closures, and changes in mission related to the GWOT. According to the GAO, "DOD performed this downsizing without proactively shaping the civilian workforce to ensure that it had the specific skills and competencies needed to accomplish future DOD missions" (p. 7). The GAO states further that the consequence of these actions is a change in the demographics of the civilian workforce, in which most of the remaining workers are older and more experienced. GAO estimated, at the time of the report, that "57 percent of the workforce [would] be eligible for early or regular retirement in the next 5 years (GAO, 2006, p. 7).

### **C. PURPOSE, GOALS, AND OBJECTIVES**

The increased technical complexity of government programs and the depletion of technical expertise in DoD, in particular shipbuilding, require an analysis of current Human Capital Management (HCM) strategies. This study investigates current DoD HCM strategies for attracting, developing, retaining and managing competencies and intellectual resources for science and engineering talent within the shipbuilding industry. The research objective is to apply Systems Engineering methods to develop a HCM architecture as a proposed solution to DoD and shipbuilding industry human capital needs for science and engineering disciplines. This study examines current DoD and shipbuilding science and engineering Human Capital issues, identifies gaps in these strategies, and suggests methods for closing these gaps. The proposed scheme provides a holistic view for consistent human resources solutions.

## **D. RESEARCH QUESTIONS**

This thesis addresses the following questions:

1. What are the current DoD Human Capital Strategies for science and engineering expertise?
  - Why were these strategies developed?
  - How are these strategies implemented?
  - Where are the gaps in these strategies?
2. How can current human capital strategies for the development, attraction, retention and management of competency and intellectual resources for science and engineering skills be improved by using Systems Engineering methodologies to examine stakeholder needs, identify gaps, and develop a notional functional model of a Shipbuilding Industry HCM architecture?
3. How does this notional architecture compare with current DoD Human Capital Management efforts?
  - How are these architectures comparable?
    - Does the notional architecture utilize components of current strategies?
    - Does the notional architecture address Stakeholder Needs?
      - Primary Needs
      - Latent Needs
    - Do the notional architectures close the gaps identified in current DoD Human Capital Management Strategies?
  - How might the effectiveness of this notional architecture be addressed?

## **E. BENEFITS OF STUDY**

Present DoD and industry training and educational systems require modification with respect to fostering skills, work flows, and methods required in the DoD workforce (starting early in high school and junior college levels). Current systems do not teach skill sets or knowledge required in DoD technical jobs because of DoD specific domain knowledge, specifically shipbuilding. HCM strategies require concentration on long-term career viability concerns for government and defense industry jobs, in particular those in shipbuilding.

Human Capital Management is the act of developing, coordinating, and managing work force skills and competencies critical to an organization's ability to perform its mission. The emphasis of this study is on the effectiveness of current DoD HCM strategies. The investigation will examine means for improving these strategies within the shipbuilding industry through the development of a notional human capital management architecture using System Engineering techniques. The development of requirements for such architectures, and the comparison of previous strategies have a profound impact on the development of a successful HCM architecture.

## **F. SCOPE AND METHODOLOGY**

This thesis analyzes DoD Human Capital Management strategies for the attraction, development, and retention and management of competency and intellectual resources for science and engineering talent for the DoD as it relates to the shipbuilding industry. It will focus on analyzing the needs of DoD's top-tier shipbuilders (such as Northrop Grumman and General Dynamics) and concentrates only on engineering disciplines such as naval architecture, naval and marine engineering (NA&ME), and similar disciplines. The emphasis of this thesis is how the effectiveness of current DoD HCM strategies can be improved using Systems Engineering techniques.

The Systems Engineering approach utilized in this study has been adapted from the 4<sup>th</sup> Edition of *Systems Engineering and Analysis*, by Blanchard and Fabrycky (2006), and is based on the conceptual design phase of a notional HCM architecture specific for shipbuilding technological skills. The six chapters of this thesis align with the Systems Engineering activities associated with the concept design phase and consist of the following:

- Chapter I – Introduction
- Chapter II – Human Capital Management (HCM) Structures
- Chapter III – Stakeholder Analysis
- Chapter IV – Gap Analysis: Assessing Human Capital Gaps In The Shipbuilding Industry
- Chapter V – Functional Analysis and Overall Measure of Effectiveness Model
- Chapter VI – Conclusions and Suggestions for Further Research

Chapter I provides background discussion of the problem, describes goals and objectives, purpose, benefits, scope, and methodology for this thesis. Chapter II provides a detailed overview of Human Capital Management, its characteristics, and management models. Chapter III performs a Stakeholder Analysis, consisting of identification, classification, and evaluation of the influence of government, industry, academic, and other stakeholders on shipbuilding industry HCM strategies and practices. Chapter IV discusses a Gap Analysis that addresses the following topics:

- What is the status of current shipbuilding industry HCM strategies?
- What are dissatisfactions with these strategies?
- Where are the gaps?
- How might these gaps be closed?

Chapter V conducts a Functional Analysis (FA) of core DoD Shipbuilding industry-specific HCM architecture functions based on the research results from the previous chapters. In addition, this chapter presents an Overall Measure of

Effectiveness (OMOE) Model as a means to facilitate trade-offs of proposed HCM architectures for the development and management of technical skills for the shipbuilding industry. The sixth, and final, chapter discusses the results of the study relative to the research questions and the potential uses of DoD Shipbuilding industry-specific HCM architectures, including areas that invite further research concerning this topic.

## **II. HUMAN CAPITAL MANAGEMENT STRUCTURES**

### **A. BACKGROUND**

Before an investigation of the issues of human capital management within DoD and the shipbuilding industry, it is first necessary to explore the idea of human capital, its strategic implications within an organization, and current structures, frameworks, and initiatives from academia and the public and private sectors.

#### **1. What is Human Capital?**

Engineering and science activities in the Department of Defense (DoD) are concerned with the development of engineered systems used in defense of the United States and its interests. In general, humans bring engineered systems into being to satisfy a need by performing designated functions in pursuit of some objective. These systems are composed of interrelated elements that when brought together interact to behave with a certain response that is not evident from the individual components acting alone (Blanchard & Fabrycky, 2006). The people that operate and maintain these systems are an integral part of the system. An engineered system may be simple or complex, but the organization that produces it requires evaluation as a complex system in its own right. Much effort is expended structuring engineering organizations, but the driving component within the organization is its people (Axelsson, 2002). Thus, an organization is a system, of which human resources and human capital are primary components.

What is human capital? In 1961, the economist Theodore W. Schultz, drawing upon observations from Adam Smith and H. von Thünen, emphasized the importance of humans as sources of capital versus what he termed conventional, or “nonhuman,” capital. Workers form a type of capital resulting from the application of their unique knowledge, skills, and abilities (KSAs), which,

like conventional capital, have economic value (Schultz, 1961). Studies performed by the National Center on the Educational Quality of the Workforce (NC-EQW) have indicated that investments in human capital have resulted in a productivity increase three times greater than the productivity increases from investment in machines and other conventional capital (Stewart, 1997).

## **2. What is Human Capital Management?**

The labels “human capital” and “human capital management” are gaining preference over the term “personnel and human resource management” and focus on the premise that employees are assets to be developed and improved through investment. As the capabilities of the people increase from this investment, value is added to the organization and its performance improves, generating greater value for clients and stakeholders. In addition, the means by which human capital is managed must be aligned with the organization’s goals, values, and mission, including what is required of the employees to achieve the desired results (United States Government Accountability Office [GAO], 2000).

However, in both private industry and the federal government this value has, until recently, been overlooked by organizations who have viewed their people not as sources for organizational success (i.e., valuable assets), but rather as costs to cut or minimize (GAO, 2003). Even when human capital factors are not overlooked, it is often difficult to understand how they interact and affect the systemic behavior of the organization. According to Jeffery Pfeffer (1994), “Success that comes from managing people effectively is often not as visible or transparent as to its source” (p. 15). The main factor separating successful firms/organizations from their competitors is the organization itself and how it manages its employees (Pfeffer, 1994).

As noted above, the traditional focus on human capital has been that it is a cost to be minimized rather than a means to increase competitive efficiency. It is rare that human capital has been looked upon as a means to create value.

Labor is the largest contributor to a firm's operating costs, thus most strategic and structural changes in business still continue to emphasize reduction in the work force as a primary means to reduce costs. However, the recent focus has changed to look upon human resources as an integral part of the firm's overall business strategy and a means to add value to the organization (Becker & Gerhart, 1996). Enhancing competitive advantage requires a change in thinking regarding the work force. To achieve competitive success, a firm must view the work force as a means to gain strategic advantage rather than a cost to be minimized (Pfeffer, 1994). There is increasing emphasis on the importance of this idea in the public sector as well. The GAO (2002) states that for federal agencies:

People are an agency's most important organizational asset. An organization's people define its character, affect its capacity to perform, and represent the knowledge-base [sic] of the organization. As such, effective strategic human capital management approaches serve as the cornerstone of any serious change management initiative. (p. 4)

The GAO goes on to state that the human capital problem is not with the employees, but with lack of a "consistent strategic approach" for managing human capital (GAO, 2002). Therefore, it is important to the success of engineered systems and by extension, the organization that designs them, that the human component is adequately structured and managed and requires consideration of structural, policy, and cultural aspects.



## **B. STRATEGIC IMPLICATIONS OF HUMAN CAPITAL**

### **1. Human Capital and Organizational Strategy**

The basis of human capital management is the idea that human capital is a strategic asset and that management practices and policies for it must be integrated with the strategic needs of the organization. Becker & Gerhart (1996) describe this idea as follows:

Strategic assets are “the set of difficult to trade and imitate, scarce, appropriable, and specialized resources and capabilities that bestow the firm’s competitive advantage.” Unlike capital investments, economic scale, or patents, a properly developed HR system is an “invisible asset” that creates value when it is so embedded in the operational systems of an organization that it enhances the firm’s capabilities. (p. 782)

Research has suggested that integration of human capital elements within the organization’s strategic plan can result in better stock performance, higher profits, improved quality, and an enhancement of the organization’s position—in other words, a means to add value to the organization. This requires the organization to evaluate human resources/human capital practices as an element of a system with particular focus on how the human elements align with the strategic objectives of the organization (Becker & Gerhart, 1996). Others suggest that organizations move from treating the human element as a simple “administrative service” by integrating their human resources/human capital professionals into the management team (GAO, 2000).

Strategic human capital planning helps management determine the workforce requirements and prepare for and identify issues that will affect the attainment of organizational goals, beginning with a clear set of goals, intents, missions, core values, objectives, and strategies for the organization. The human capital management approach flows and is developed from a combination of these factors (GAO, 2004). Alignment with these factors is dependent upon the degree to which the organization integrates them into its daily activities. In

addition, it is important to measure the effectiveness of human capital management practices to assess the degree to which they support and facilitate the organizational goals, values, and mission (GAO, 2000).

## **2. Core Competencies and Competitive Advantage**

A prime enabler for the development of an organization's human capital are the competencies of its people, which can be defined as the "set of behaviors that encompass knowledge, skills, abilities, and personal attributes that are critical to successful work accomplishment. They describe what the employees know, what they do, how they do it and translate into effective on-the-job performance" (GAO, 2004, p.2). Thus, competencies are the factors that contribute to people's worth as capital.

These skills come in three forms: commodity skills, leveraged skills, and proprietary skills. Commodity skills are obtained easily, are not unique to the business (thus equally valuable to most businesses), and are transferred easily. Leveraged skills are those skills that are not specific to a firm but are desired generally within an industry, thus, making them more valuable to some organizations than for others. Finally, proprietary skills are those attributes and talents on which an organization depends for its business and give it a distinct identity within its industry (Stewart, 1997). Shipbuilding industry examples of commodity skills for technical employees would include drafting and tool-related experience and fundamental engineering sciences knowledge, such as computer aided design and drafting (CAD), finite element analysis, and mechanical and electrical engineering. Leveraged skills would include industry specific skills such as naval architecture and marine engineering (NA&ME), and radar and weapons systems integration. Proprietary skills would include specific manufacturing processes (such as composite structures design, unique welding procedures) and analytical techniques related to stealth characteristics, hydrodynamics, and electrical propulsion (Toner, 2005).

A firm that can develop and make use of the proprietary competencies of its people can develop capabilities that differentiate it from its competitors and enhance its competitive advantage. It has been argued that differences in the traditional measures of a firm's success (i.e., between the market and book value of a firm's assets) result from the skills of the employees. The resource-based view of the firm postulates that a firm gains competitive advantage through value creation mechanisms that are unique to the firm and are not duplicated easily by competitors. That is, while natural resources, technologies, economies of scale, and such, are increasingly easier for competitors to imitate, the handling of the people within an organization (the employment system) is not (Becker & Gerhart, 1996).

Professional services firms, in this case firms that provide science and engineering expertise, rely on the uniqueness of their work staffs. If the skills of the work staff can be acquired easily from outside sources, the competitiveness of the firm is diminished. Thus, organizations should devote energy to developing a work force with skills that their competitors cannot duplicate easily. Additionally, the firms should endeavor to maintain this skill set. Given the rapid pace of technological change, these critical skills can atrophy (Pfeffer, 1994). Furthermore, it is necessary that the firm concentrate these skills through organizational structures (i.e., the human capital management system) that facilitate collaboration and knowledge sharing (Stewart, 1997). As Becker & Gerhart state, this systemic structure will be difficult to duplicate because it is necessary to understand the interrelation between the various elements and components. This interaction may be "additive or multiplicative" or may include "complex nonlinearities" (Becker & Gerhart, 1996, p. 782). The human resource/human capital portions of the system form a social mixture of culture and interpersonal interactions that make it difficult for an outsider to understand the manner in which human capital mechanisms are utilized to create value within an organization. Without this understanding, it is impossible to duplicate

the system and generate similar results (it cannot be “reverse engineered”). In addition, the uniqueness of the mechanism prevents a competitor from simply buying it on the open market (Becker & Gerhart, 1996).

To achieve this advantageous state, it is necessary to align the critical KSAs with the strategic goals and needs of the organization. Significant emphasis should be placed on training that targets the development and sustainment of the specific leadership qualities, competencies, and behaviors that are required for high performance. Thus, strategic work force planning requires a consideration of hiring, training, development, and performance management strategies to address gaps in the current state of the organization’s human capital structure and nurturing of the skills and competencies required for future success (GAO, 2000, 2004). Chapter IV will revisit the issue of gap analysis in detail.

During the literature review for the prior discussion of competitive advantage gained through effective human capital management structures and practices, the difference between private industry (in particular the shipbuilding industry) and the Federal Government was noted on several occasions. The government does not operate for profit or economic efficiency as in private industry, but rather in the public interest. However, government agencies have much to gain in terms of organizational performance and increased efficiency through improved human capital practices. The motivations are similar but focus on different goals. Attention now turns to investigation of the aspects of structures that facilitate the development of an organization’s human capital management system.

## **C. HUMAN CAPITAL MANAGEMENT STRUCTURES AND PROCESSES**

### **1. Best Practices versus Best Fit Structures**

Different views exist regarding the nature of human capital management. One view is that human capital management consists of a set of “best practices” that generally apply to organizations. In contrast, others are proponents of a system view consisting of a “best fit” of human capital management configurations based on the organizational system. Yet others take a middle ground and propose that a combination of both concepts is most appropriate (Becker & Gerhart, 1996).

As a proponent of the best practices model, Pfeffer (1994) has developed a set of sixteen best practices for managing human capital (see Table 1). These practices consist of themes viewed as common among organizations that effectively manage their people. The premise is that application of these practices is independent of the organizational strategy. Pfeffer argues that while factors such as the organization’s circumstances—type of industry, level of technological development, and location, among others—change the form in which the practices are implemented, the principles embodied within the set of best practices is constant. Successful application of the best practices depends instead upon a consistent management philosophy based on the values and beliefs espoused by management regarding the definition of success and effective handling of people. This management system is the “glue to knit things together” (p. 59).

Best Practice	Description
1. Employment Security	This practice demonstrates management's commitment to the employees and frees workers to concentrate on the job. This practice helps to generate loyalty and a willingness to expend extra effort.
2. Selectivity In Recruiting	Rigorous and selective recruiting sends an impression regarding the organization, sets high standards and expectations, and sends a message that people matter.
3. High Wages	More attractive to prospective employees and reduces attrition in current workers (less likely to search for higher paying jobs). The organization silently demonstrates that it values its employees, while workers are willing to be more productive.
4. Incentive Pay	If people are responsible for gains from higher performance, then it is logical that they will want to share in the reward, as long as it is equitable and fair. Team-based requires reduce rivalries and political behaviors.
5. Employee Ownership	Giving the employees a share in ownership makes them primary stakeholders in the destiny of the company. This encourages a long-term focus from the employee and protects the company from buyout offers or hostile takeovers.
6. Information Sharing	Open sharing of information with employees helps them to understand the state of the business and facilitates understanding of the rationale behind management decisions.
7. Participation and Empowerment	Giving employees a greater role in decision-making and control of the workflow enhances employee satisfaction and productivity. When used in conjunction with information sharing, employees are better able to suggest improvements.
8. Teams and Job Redesign	Changes individual behaviors based on group conformance with respect to behaviors, work quality, and work performance. Facilitates sharing of information and consistency.
9. Training and Skill Development	Critical importance is placed on allowing employees to implement the benefits of the training to job activities. Structures that do not allow this negate the effect of the training.
10. Cross-Utilization and Cross-Training	The more jobs an employee can perform, the more interest he/she will have in their work. Familiarization with multiple tasks makes it easier to keep an employee on staff during economic downturns. Additionally, insights may be gained in other areas of the business due to insertion of different perspectives from other departments.
11. Symbolic Egalitarianism	Mixing the managers with the employees (no private suites, offices, or parking spaces, etc.) removes the barriers between management and employees and facilitates understanding and communication.
12. Wage Compression	Large disparities in how wages and salaries are distributed can induce employees to act politically to gain favor and "game the system" to get higher compensation. By taking attention off of pay differences, the culture becomes less "calculative" and the message is sent that there is no difference between employees—everyone matters.
13. Promotion From Within	By promoting from within, the new manager is more likely to both know the business and the people he/she will manage than someone hired from the outside. This practice "provides a sense of fairness and justice in the workplace."
14. Long-Term Perspective	The gains derived from implementing work force changes take a long time to develop. Management must look beyond short-term fixes and give the implemented practice time to manifest itself in terms of enhanced competitive advantage.
15. Measurement of the Practices	Metrics drive performance, affect behavior, and give insight into the effects of policy changes. Metrics give management the ability to determine if it is doing what it says it will do and provide the visibility needed to continue commitment to the implementation of the policy change.
16. Overarching Philosophy	Provides a consistent means by which practices are integrated into a coherent whole and is guided by management's core values and beliefs with respect to how the business is run and employees are managed.

Table 1. Pfeffer's Sixteen Human Capital Best Practices (After Pfeffer, 1994)

Despite this view, research has suggested that human capital best practices are manifested in the manner in which the human capital management system is structured (i.e., “architected”). According to Becker & Gerhart (1996) “There appears to be no best practice magic bullet short of organizing a firm’s HR system from a strategic perspective” (p. 797). In other words, a particular best practice feature would be incorporated as a property of the architecture of the system. These features must be aligned with the human capital system architecture to generate the desired improvement effect. The choice of which features to include depends upon the circumstances and approaches undertaken by a particular firm. In addition, while one organization’s practices may significantly differ from those of another, it is possible to implement them within similar structures and achieve organizational success. Further research suggests that human capital management based on a system approach that supports the organization’s HR strategies instead of implementation of “best practice” HR strategies will have the greatest benefit. Therefore, a consistent fit between the HR system, HR policies, and organizational strategy must be obtained. The greatest strategic advantage is obtained through a “properly configured HR system” (Becker & Gerhart, 1996, p. 797).

## **2. Four-Quadrant Human Capital Architectures**

The four-quadrant human capital architecture model, as posed by Lepak & Snell (1999) was developed to address the issue of how to orient a firm’s human capital configuration with its strategic goals. Development of the model begins from the idea that a firm is faced with a decision regarding its human capital: seek an internal solution to foster development and training of critical skills and competencies, or seek the required talents from outside the organization on the open labor market. Like other forms of capital, the firm faces a “make or buy” decision. Choosing to develop the human capital, or “internalizing” it, carries with it a management cost for development and sustainment. This includes the

benefit that the firm will experience greater long-term continuity in critical skills but with the risk that the firm may not have the flexibility to respond to changes in the external environment. Choosing to acquire human capital, or “externalizing” it, helps decrease management costs and allows greater flexibility to the firm with regard to workforce size and decreased overhead costs. However, the firm risks sacrificing the development of critical skills to attain short-term gains.

The premise of the four-quadrant model is that most firms use a mixture of internal and external approaches, or employment modes (Lepak & Snell, 1999). Despite the tendency in human capital research to favor human capital management systems with a single uniformly applied HR configuration no matter what tasks employees perform or what skills they possess, Lepak & Snell argue that a single architecture for human capital management may not be appropriate.

Rather, because different employee groups have different KSAs, a single organization may employ different HR configurations and employment modes within a single architecture. Each configuration and employment mode represents a different employee group (i.e., type of human capital) within the organization (Lepak & Snell, 2002).

The principal drivers of the employment modes within an organization are the strategic value of its human capital (i.e., how it gives the firm competitive advantage and facilitates improvements in efficiency and the addition of value) and its uniqueness (i.e., the degree to which it is specific to the organization and the ease with which it is duplicated—or not—by competitors). Competitive advantage is critically dependent on the firm’s core competencies, which are responsible for production of the goods and services that directly contribute to the customer’s perception of value. The value of human capital is therefore defined in terms of the enhancement of customer value through human capital development relative to the development cost incurred (Lepak & Snell, 1999).

The uniqueness of a skill and the lack of ability of other firms to duplicate it is another source of competitive advantage. As noted earlier, the development of



this unique skill is dependent upon the internal social and structural dynamics within the organization and is very difficult to duplicate. In addition, the more characteristic a core skill is to an organization, the harder it becomes to acquire it from external sources. This suggests that organizations look to develop the skill internally. Common (peripheral) skills that are available to all firms may be cheaper to obtain from external sources. The degree of uniqueness has an influence on the balance between internalization and externalization of human capital. Therefore, as an architecture, the four-quadrant model examines the relationships between the employment modes and forms of human capital used within the firm against the two dimensions of value and uniqueness, as depicted in Figure 4 (Lepak & Snell, 1999).

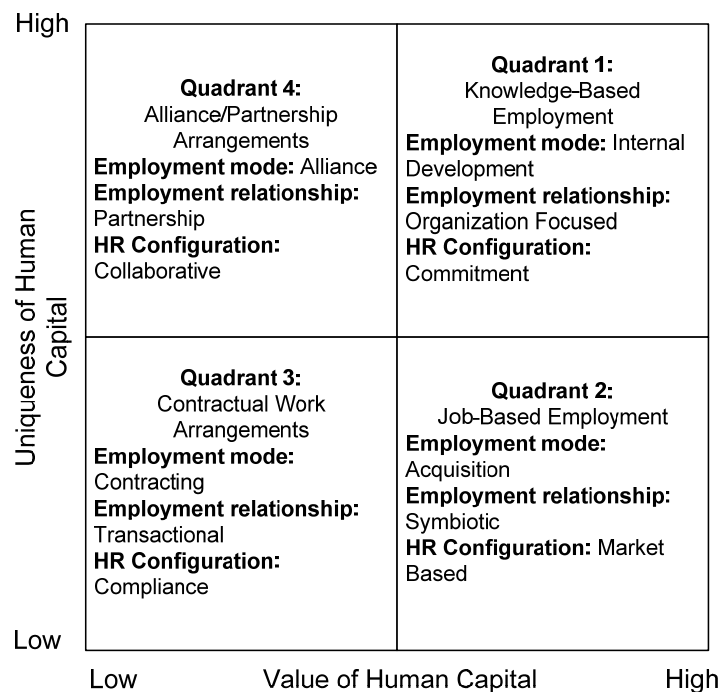


Figure 4. Summary of the HR Architecture Model (After Lepak & Snell, 1999; 2002)

The human capital in Quadrant 1 has a high strategic value and is unique. This quadrant contains the firm-specific skills that cannot be bought and must be

developed internally by the firm. There are strategic and economic incentives for the firm to pursue internal development of this form of human capital. In this case, the strategic benefit derived from developing this type of human capital is greater than the cost to develop and utilize it. Employees in this quadrant, due to the specialized knowledge and skills they possess, are essential for attaining competitive advantage. The basis for the relationship between the firm and the employees in this quadrant is the level of employee commitment. The employees are provided incentives for higher performance and long-term service through a corresponding commitment from management to invest in and encourage their skill development, involve them in decision making activities (i.e., empower them), and reward and compensate them based on team-based activities and the acquiring and mastering of core competencies (Lepak & Snell, 1999).

The human capital in Quadrant 2 has high strategic value but is widely available in the labor market and is transferred easily between firms. Due to the high value and relative non-uniqueness of this form of human capital, management is forced to decide whether to incur the cost to develop it internally, or to purchase it on the labor market. In this quadrant, the latter prevails as the mode of employment, since employees can essentially sell their services to the highest bidder. Therefore, the relationship between employees and management is based on the symbiotic need for the firm to utilize the employee's highly valued, yet non-unique, skill and for the employee to gain the career-oriented benefits derived from the relationship. So long as both are satisfied, the relationship continues. Since the skills employed are not unique, the firm is less likely to invest in their development, since there is greater risk that the employee may leave. Rewards and compensation, in contrast to Quadrant 1, are based more on employee performance and productivity in specific jobs (Lepak & Snell, 1999).

Human capital in Quadrant 3 is of low strategic value, is not unique, and can be treated as a commodity. Therefore, it is not in the economic interests of the firm to develop this human capital internally. Employment for this type of human capital is typically via contractual arrangements with outside entities. The benefit is reduced overhead and added flexibility for the firm in terms of employment duration and number of workers. The employment relationship is purely transactional. That is, it is based on short-term economics, and little commitment on the part of the employee is expected. The HR configuration is based upon compliance with policies, procedures, and regulations and little is expended on training, except in reference to company policies and procedures. The degree of compliance with policy and procedure form the likely basis for compensation (Lepak & Snell, 1999).

In Quadrant 4, human capital has a higher degree of uniqueness, but does not directly contribute to enhancement of the firm's strategic position. Because of its limited value, there is temptation to develop the skill internally; however, this may be prohibitive for the firm in terms of cost, time, or both. Therefore, the firm resorts to a partnership or alliance with another firm and shares responsibility (and cost) for development at the benefit of accessing the other firm's competencies. Both parties share in the outcome of the relationship. Each firm has specific knowledge that may be useful to the other, so the basis of the relationship is collaboration, information sharing, and the development of mutual trust. The focus of training in this quadrant is team building, communication, and process development (Lepak & Snell, 1999).

Stewart (1997) proposes a similar model based on the four-quadrant idea. As shown in Figure 5, the model focuses on the value added by the human capital type and the difficulty of replacing it. In the lower left quadrant are those individuals that have common skills that are not particularly unique to the organization. These individuals are interchangeable, quickly replaced, and require little or no training. The upper left quadrant contains those individuals

that perform necessary, but relatively low value tasks. These individuals have skills based on direct job experience and are harder to replace. The individuals in the lower right quadrant are those that produce high value work. However, they have leveraged skills--skills and knowledge that are not unique to the company, but are more valuable to the organization relative to its competitors. The upper right quadrant contains the individuals that are hardest to replace because they do the highest value work—that which gives competitive advantage. These individuals are considered irreplaceable because they have the proprietary skills that were developed internally (Stewart, 1997).

Similar to the Lepak & Snell concept, the upper right quadrant is the nucleus of the firm's human capital and is responsible for developing the products and services that provide competitive advantage and provide customer value. This quadrant is an asset to the firm, while the others are viewed simply as labor costs. Essentially, the more work performed in the upper right quadrant, the greater the utilization of the firm's hard-to-replace human capital (Stewart, 1997).

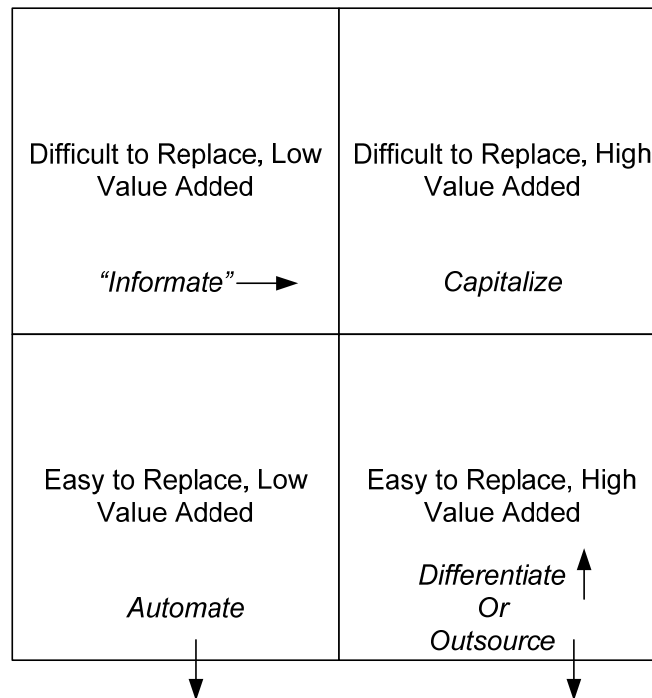


Figure 5. Stewart's Four-Quadrant Human Capital Model (After Stewart, 1997)

In Stewart's version of the model, individuals in the lower right quadrant may be outsourced. However, the firm may elect to develop this human capital by customizing their transferable skills in ways that make them more specific to the company and move them closer to the valuable upper right quadrant. Individuals in the upper left quadrant can have their work "informed." That is, by enhancing the value of the related information, the results of their work becomes more beneficial to the customer. Therefore, the overall value of their contribution is increased. Individuals in the lower left quadrant are candidates for outsourcing or having their jobs automated. Thus, in Stewart's view, management's goal should be to move as many of the value-producing individuals toward the upper right quadrant as possible, while automating or outsourcing those skills that are not particularly valuable to the firm (Stewart, 1997). In contrast, the Lepak & Snell concept takes a slightly different view,

acknowledging the necessity to retain various proportions of human capital from each quadrant simultaneously (Lepak & Snell, 2002).

The environment in which the firm operates will change over time. Thus, it is possible for an organization's human capital to decay in either the value or the uniqueness dimension, or both, with a corresponding loss of competitive advantage, as depicted in Figure 6. In order to maintain its competitive advantage (prevent decay), the firm must continually search for new ways to improve its human capital. For example, a firm can enhance the uniqueness of existing employee skills through development of unspoken institutional knowledge, making them harder to duplicate (moving its human capital from Quadrants 2 and 3 to Quadrant 1, as indicated in Figure 6). Alternatively, the firm can extend core skills and knowledge to other areas of the business such that the application of the skills increases the value delivered to the customer (shifting its human capital from Quadrants 3 and 4 to Quadrant 1). Finally, it may

be necessary to redistribute the human capital by changing the HR configuration or employment mode based on changes in the strategic position of the firm (Lepak & Snell, 1999).

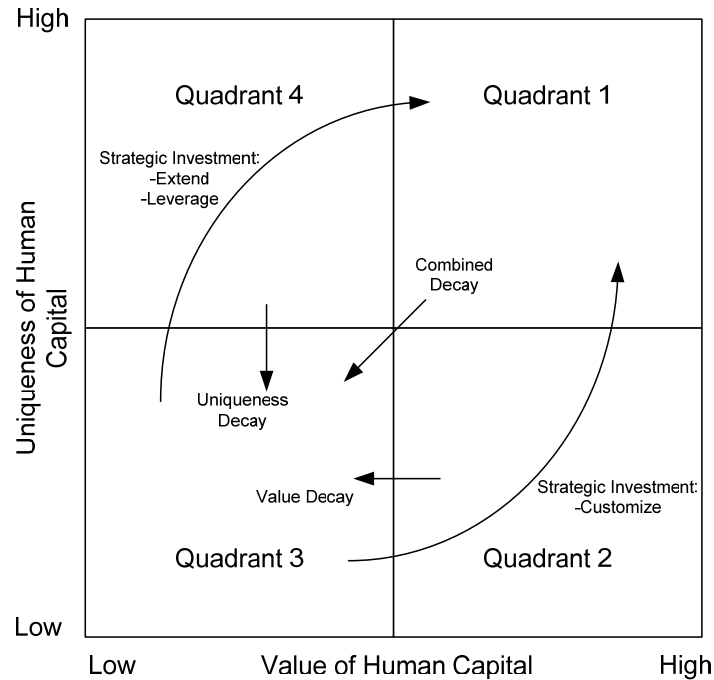


Figure 6. Dynamic of the Lepak & Snell HR Architecture Model (After Lepak & Snell, 1999)

#### D. HUMAN CAPITAL MANAGEMENT FRAMEWORKS

The discussion to this point has emphasized the strategic importance of human capital management and has suggested structures and modes in which an organization should acquire and manage the various types of human capital available to it. However, the strategies suggested fall short of suggesting the means by which the organization implements and develops its human capital strategy. This section discusses a suggested means for establishing and developing an organization's human capital management processes, the People Capability Maturity Model (People CMM), and shows two adaptations of this model as examples.

##### 1. The People Capability Maturity Model (People CMM)

The People Capability Maturity Model (People CMM) is an evolutionary outgrowth of the Software Capability Maturity Model (SW-CMM) developed by

the Software Engineering Institute (SEI) at Carnegie Mellon University. SEI developed the SW-CMM out of the need to provide a means for software firms to improve the quality of their products, decrease development costs, and improve customer satisfaction. The SW-CMM focused on establishing and documenting the firm's product development processes and how to evolve them through different stages of maturity to facilitate continuous improvement of both the processes and the product. Over time, firms using SW-CMM determined that it was not only necessary to manage and improve the processes and procedures used to develop their product, but also the processes and procedures for management and development of the people responsible for the production. The result was creation of the People CMM framework, originally developed by SEI in 1995, and updated to Version 2.0 in 2001. The intent of People CMM is to provide a means for a firm to develop and improve continuously its work force in a manner similar to that used to improve business processes related to product development. The ultimate aim of implementing People CMM is to alter the culture of the organization from one that haphazardly manages its human capital to one that values the professional development and improvement of its work force (Curtis, Hefley, & Miller, 2001).

The People CMM starts with a definition of five levels of maturity, as shown in Figure 7. Each level represents an evolutionary state in which the organization has reached a certain level of capability with regard to its work force practices. The attainment of a particular level serves as a foundation for progressing to the next level of maturity. The Initial Level (Maturity Level 1) is a state in which the firm has established no consistent work force practices. This low level of maturity is characterized by:

- Inconsistent and undocumented workforce processes and practices,
- Displacement of management responsibility for guiding and developing the work force to other groups or individuals,



- Performance of practices, such as training, recruiting, and performance evaluation in a ritualistic manner without regard to their impact, and
- A work force that acts according to individual goals without consideration of those of the business.

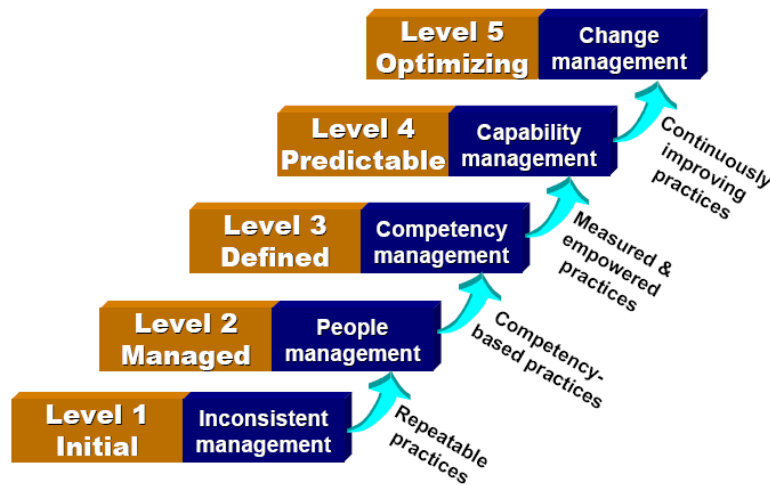


Figure 7. The five maturity levels of the People CMM (From Curtis, Hefley, & Miller, 2001)

The result is an organization that cannot consistently manage its employees, has trouble attracting and retaining its talent, and depends upon the individualized, and sometimes extraordinary, skills and efforts of certain managers for effective work force management (Curtis, et al., 2001).

At the Managed Level, Maturity Level 2, management commits to development of work force processes and practices at the unit level. The initial unit-level focus avoids implementing organization-wide changes that are beyond the organization's ability to manage relative to its level of maturity. Attempting such extensive changes too early overwhelms the effort. Instead, individuals within the work group begin to document the work force practices employed, such as interview processes, recruiting, and conducting performance assessments, among others. By documenting these processes and practices,

they become repeatable and consistent, facilitating a stable unit-level work environment. Unit level managers focus on implementing these processes to improve performance of the individuals in the group and thereby increase the effectiveness of the work group. This serves as a precursor state toward greater consistency across the organization. A benefit from the stable work environment is a decrease in employee turnover through improved relations between the employees and their immediate management (Curtis, et al., 2001).

Building on the repeatable practice foundations of Maturity Level 2, the Defined Level, or Maturity Level 3, examines the work force practices of each unit to find common attributes (i.e., common knowledge, skills, and abilities—competencies). This effort expands the previous unit-level developments across multiple work groups and facilitates consistent practices at the organizational level. The firm identifies work force practices that can be standardized. Competencies that exist within these practices are integrated as best practices and are linked to the firm's core competencies and strategic goals. This activity allows management to shift its attention to finding ways to motivate individuals to develop and improve work-related competencies and serves as the entry point for formation of the human capital architectures discussed in prior sections. The standardization across work groups facilitates consistency and simpler, more efficient operation while decreasing the dependency on individual heroic efforts experienced at Maturity Level 1. As the work force becomes more confident and competent, it is better able to participate in business decision-making. The benefit is a cultural shift to that of a professional organization that encourages employee participation and rewards them for the increased capability and performance that results (Curtis, et al., 2001).

At the Defined level, the organization has developed the structure and means for developing its work force. At Maturity Level 4, or the Predictable Level, the organization begins to analyze its workforce quantitatively. The firm's performance of processes dependent upon the established critical competencies

is measured and performance baselines are established. Quantitative evaluation against these baselines allows the firm to predict the capacity and ability of the work force and forms the basis for determining areas for improvement or corrective action. The organization benefits in three ways:

- A competent workforce performing consistent and well defined competency-based processes generates results that management can trust.
- The trust generated gives management confidence to empower work groups to perform at increased levels of responsibility and authority, freeing it to concentrate on strategic issues.
- Mastery of individual work-group competency-based processes allows the firm to begin examining ways to integrate these processes where they share dependencies into larger multidisciplinary processes, thereby reducing business cycle time.

With quantitative data, management gains the necessary insight into the work processes to facilitate better decision-making and increase the accuracy of performance predictions (Curtis, et al., 2001).

Finally, at Maturity Level 5, the Optimizing Level, all parts of the organization have established a foundation upon which a state of continuous improvement can be achieved. Organizations at Level 5 view continuous improvement as a regular and orderly part of everyday business. Work practices are evaluated for the degree to which they support work group performance objectives and align with organizational strategic goals. The latest developments in work force practices are evaluated for applicability and alignment with organizational goals, and data are analyzed to identify potential innovations. The culture has evolved to one of performance excellence in which both work groups

and individuals strive to identify areas at both the individual and work group

levels in which improvements to competency-based processes can be implemented (Curtis, et al., 2001).

Within each level of the People CMM, with the exception of the first level, three to seven process areas identify groups of related work force practices. These processes are different at each maturity level and exist at the individual levels. When performed consistently within a maturity level the practices allow a firm to achieve its goals relative to developing the capabilities of its work force. As indicated in Figure 8, individual process areas are linked across maturity levels by four areas of concern, called process area threads. These are, Development of Individual Capabilities, Building of Workgroups and Culture, Motivating and Managing Performance, and Workforce Shaping (Curtis, et al., 2001).

Maturity levels	Process Area Threads			
	Developing individual capability	Building workgroups & culture	Motivating & managing performance	Shaping the workforce
<b>5</b> Optimizing	Continuous Capability Improvement		Organizational Performance Alignment	Continuous Workforce Innovation
<b>4</b> Predictable	Competency Based Assets Mentoring	Competency Integration Empowered Workgroups	Quantitative Performance Management	Organizational Capability Management
<b>3</b> Defined	Competency Development Competency Analysis	Workgroup Development Participatory Culture	Competency Based Practices Career Development	Workforce Planning
<b>2</b> Managed	Training and Development	Communication & Coordination	Compensation Performance Management Work Environment	Staffing

Figure 8. Process Area Threads in the People CMM (From Curtis, et al., 2001)

As indicated in the figure, the process areas and process area threads intersect at each maturity level to form a matrix mapping of the processes and objectives in the People CMM. This framework provides the means by which an

organization classifies and targets human capital issues and begins to manage, develop, and improve its workforce systematically (Curtis, et al., 2001). As an example, when addressing the Development of Individual Capabilities thread at Maturity Level 2, the firm establishes Training & Development practices at the work group level based on immediate training needs.

These established processes and practices form the foundation for transformation into Competency Analysis and Development practices at Maturity Level 3, in which the organization's work force competencies are identified and programs are developed to provide employees with the opportunity to develop those competencies. At Maturity Level 4, the competencies developed at Level 3 are used to create mechanisms to share and propagate competency-based processes across the organization (Competency Based Assets) and among individuals via Mentoring.

At Maturity Level 5, the capabilities developed via progression through the previous levels are improved at the organizational and individual levels (Curtis, et al., 2001). By focusing on each process area thread and the processes and practices embodied at each level, an organization begins disciplined development of its human capital, moving from an organization that haphazardly treats human capital issues to a mature organization that strategically manages its human capital to gain competitive efficiency and advantage.

## **2. Tailored Adaptations of People CMM**

Several commercial organizations have applied the People CMM framework, including Lockheed Martin, Boeing, and AIS in the United States and Tata Consultancy Services, Mastek Limited (IT), IBM Global Services India, CG Smith, Cognizant, and i-Flex in India (Curtis, et al., 2001). In addition, adaptations of the idea of applying maturity models loosely based on People CMM have been developed and proposed for use in U.S. Federal Government agencies. This section describes two adaptations. The first is a proposed

framework developed by the Center for Innovation in Public Service (CIPS) and the other is a suggested framework developed by the GAO.

**a. CIPS Strategic Human Capital Management Framework**

The CIPS Strategic Human Capital Framework was developed in 2006 to address human capital issues driven by concerns resulting from the retirement of the baby boomer cohort, changes in government personnel processes (for example, the National Security Personnel System (NSPS)), presidential and congressional mandated government agency performance initiatives, and the Homeland Security Act of 2002. The specific focus of the framework is to provide a means for agency leaders to analyze their HCM needs, with particular focus on treating employees as critical assets; strategic management and planning of employee skills; prioritization and planning of human capital costs for sustained investment; and enhancement of communication and collaboration with employees (Center for Innovation in Public Service [CIPS], 2006).

In a manner similar to the Process Area Threads from People CMM, the CIPS HCM framework establishes various human capital components as areas of focus, as summarized in Figure 9. Next, the CIPS framework devises a series of steps related to the phases of implementation for human capital processes used within an organization. These are categorized in terms of strategy, implementation, and results. Strategy is concerned with the high-level drivers that determine the direction of HCM within the organization. Implementation refers to the means by which the organization brings a program into being, nurtures its development, maintains it, and measures its

effectiveness. The Results category represents evaluation of the effectiveness of implementing a human capital program within the agency. These are shown in Figure 10 (CIPS, 2006).

Like People CMM, the CIPS framework incorporates a progression through maturity levels, using four levels (instead of the standard five levels as defined by the Software Engineering Institute). As in the People CMM framework, each level represents an evolutionary state for the organization. In this case, the focus is the degree to which the subject agency values its people. As shown in Figure 11, these levels range from “People-Averse,” in which there is little understanding of HCM practices, to “People-Centric,” in which the organization views its people and their development as a critical factor in organizational effectiveness (CIPS, 2006).

To form the framework, CIPS integrates the HCM components and framework steps at each maturity level, as shown in Figure 12. An example of this integration for the “Recruitment and Hiring” component (as noted in Figure 9) is shown in Figure 13. Within the cells of the resulting matrix are performance metrics related to the steps and sub-steps in the human capital management processes for each maturity level. The framework, as constructed is now employed as a tool to assist an organization’s self-assessment regarding its maturity level with respect to each step in the human capital process. Thus, an organization can use the framework in checklist form as a first step in assessing its human capital gaps. Figure 14 gives an example as applied to the “Recruitment and Hiring” component (CIPS, 2006). A complete presentation of this framework is presented in Appendix A.

<b>Recruitment and Hiring</b>	Includes efforts related to attraction, selection, and formal acceptance of new employees.
<b>Retention</b>	Includes efforts that ensure high-performing employees remain with the organization. High-performing employees are treated as assets vital to the organization's success.
<b>Staff Development</b>	Includes efforts aimed at providing employees with the necessary skills to meet their job responsibilities.
<b>Workforce Planning</b>	Efforts related to aligning HCM with the organization's mission.
<b>Performance Management</b>	How an organization identifies employee responsibilities, aligns the responsibilities with organizational performance, and monitors performance to ensure that high performance can be rewarded and low performance can be effectively addressed.
<b>Information Sharing</b>	How an organization ensures that knowledge is collectively distributed and utilized by employees. Practices ensure that this knowledge contributes to employee performance.
<b>Personnel Transaction Support</b>	Efforts typically identified within a human resource office. Efforts include payroll, benefits, separation, and other paperwork/processing activities.

Figure 9. CIPS Human Capital Management Components (From Center for Innovation In Public Service [CIPS], 2006)



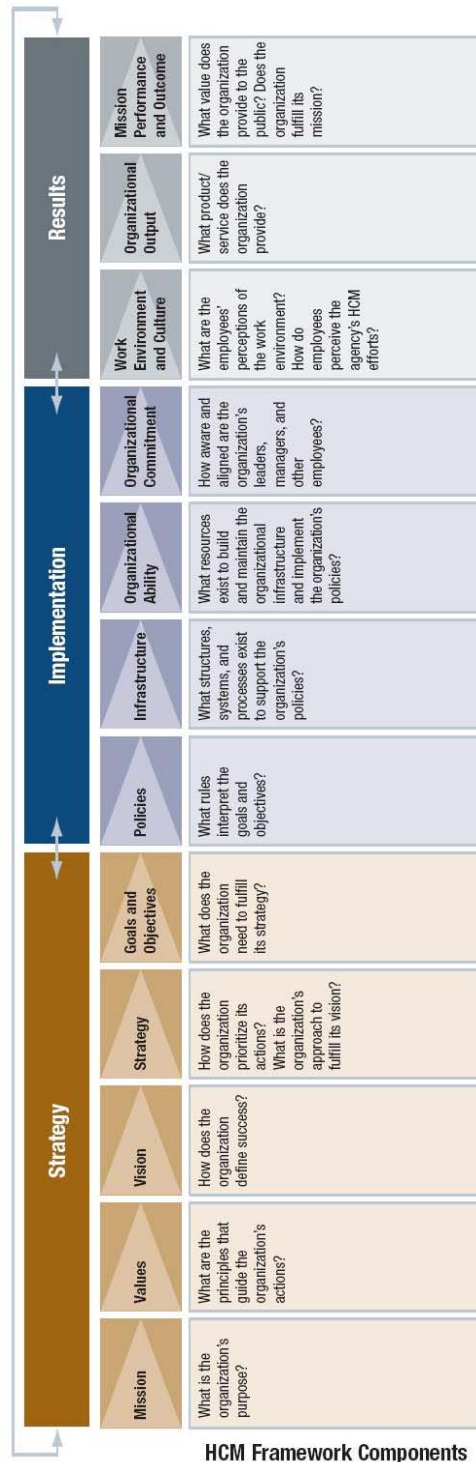


Figure 10. CIPS Human Capital Management Framework Steps (From CIPS, 2006)

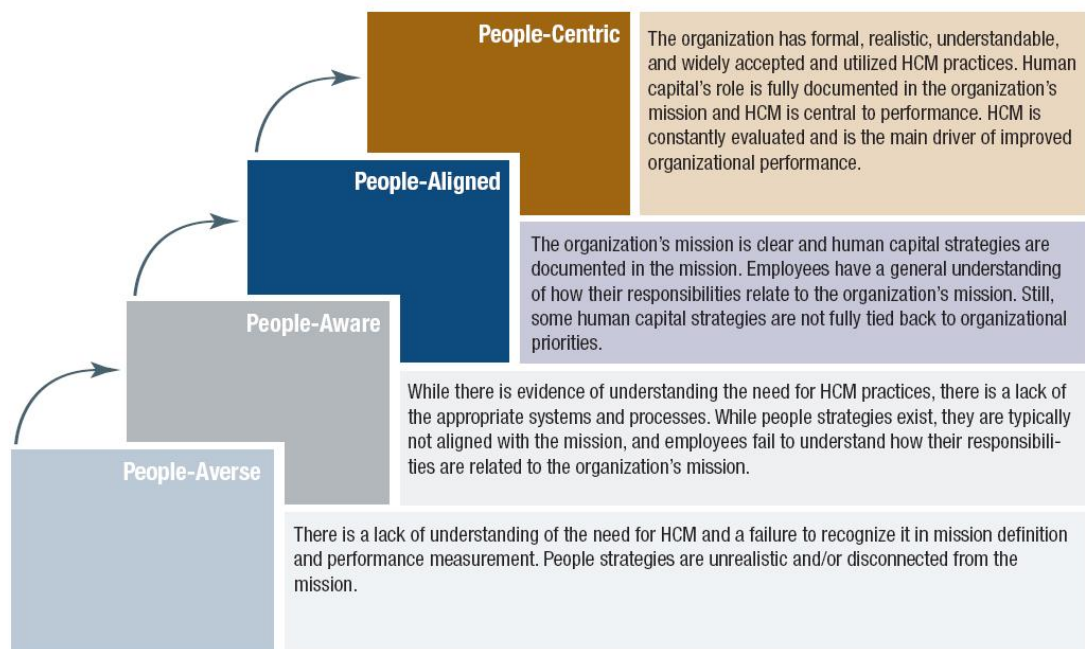


Figure 11. CIPS Human Capital Management Framework Maturity Levels (From CIPS, 2006)

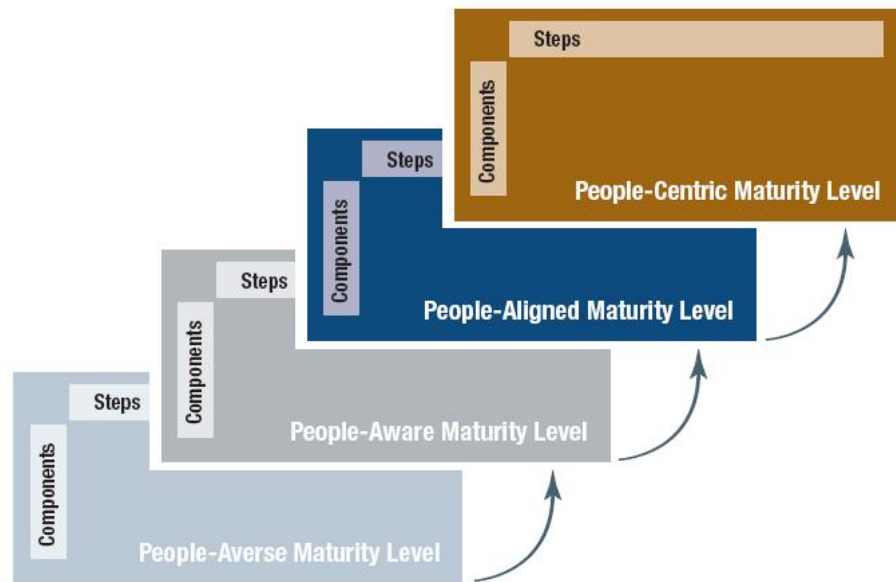


Figure 12. CIPS Human Capital Management Framework Skeleton (From CIPS, 2006)

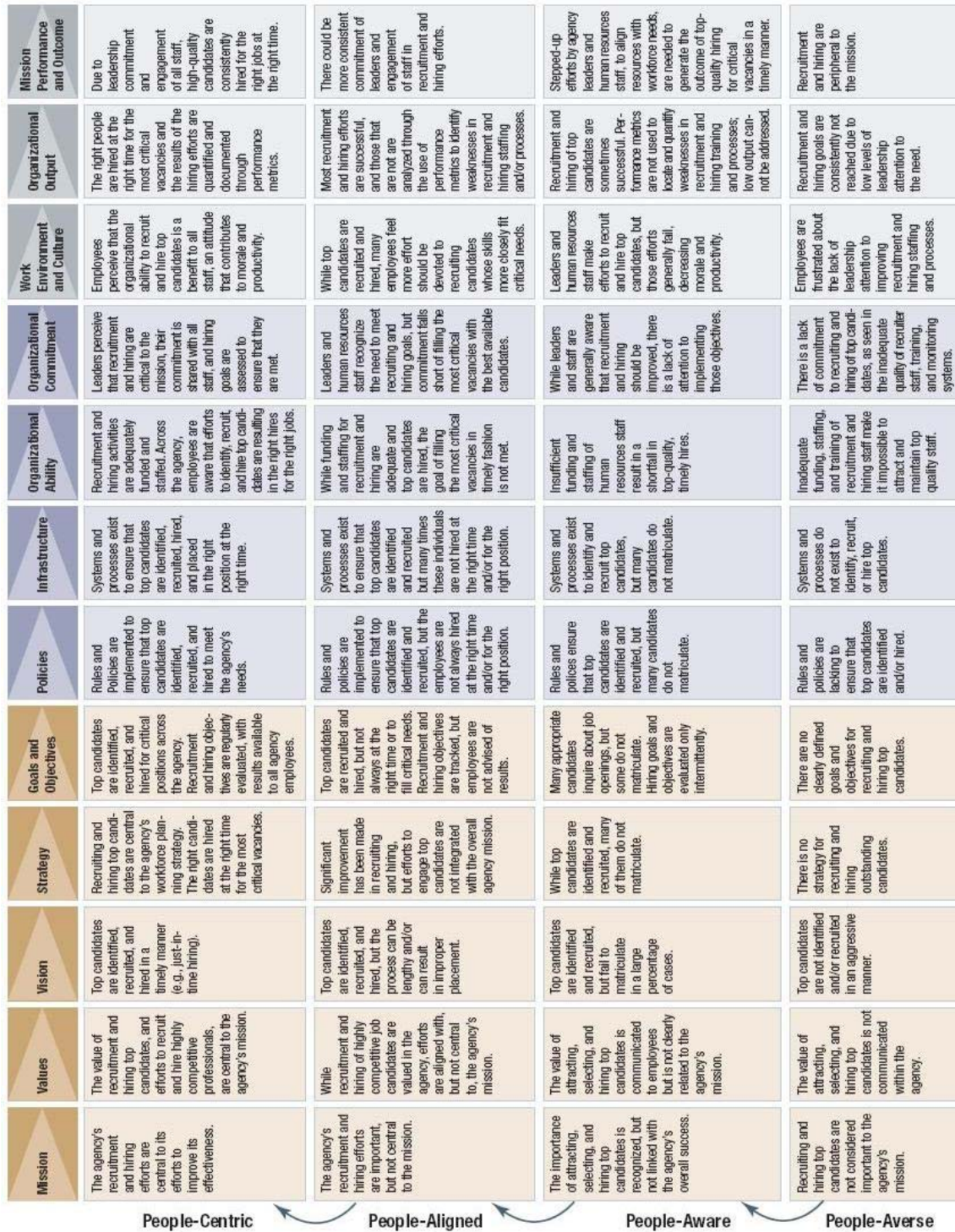


Figure 13. Example of CIPS Human Capital Management Framework for the Recruitment and Hiring HCM Component (From CIPS, 2006)

Mission		X		
Values		X		
Vision		X		
Strategy		X		
Goals and Objectives		X		
Policies		X		
Infrastructure			X	
Organizational Ability			X	
Organizational Commitment		X		
Work Environment and Culture			X	
Organizational Output			X	
Mission Performance and Outcome			X	

People-Centric    People-Aligned    People-Aware    People-Averse

Figure 14. CIPS Human Capital Framework Sample Assessment for the Recruitment and Hiring HCM Component (From CIPS, 2006).

**b. CIPS and People CMM Frameworks Compared**

The main differences between the CIPS model and the People CMM are that they utilize a different number of maturity levels (People CMM uses five levels, while the CIPS framework employs only four); and the areas of focus in the models differs slightly. Regarding the focus areas, in terms of the People CMM process area threads, the seven CIPS HCM Framework components align mostly with the “Shaping the Workforce” thread from People CMM (see Figure 15).

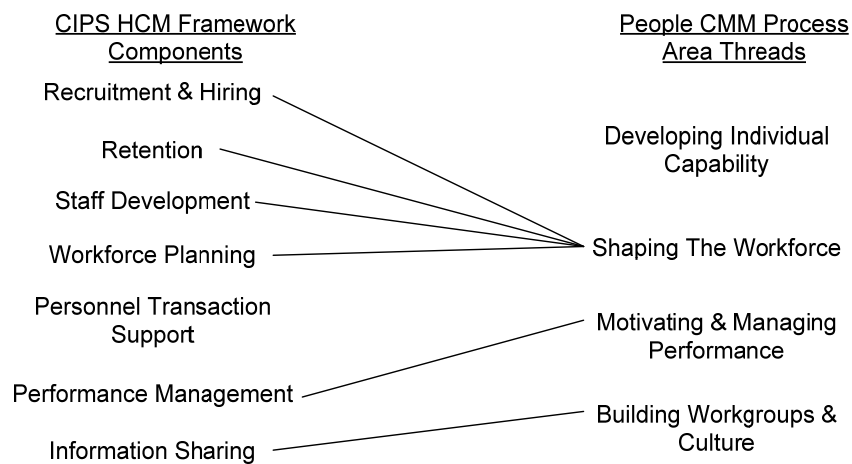


Figure 15. Comparison of the focus areas in the CIPS HCM Framework and the People CMM

Thus, the application of the CIPS framework appears somewhat narrower than in People CMM. However, this is due primarily to the focus of the CIPS study, which was specifically to address improvement of the hiring, retention, performance management, and compensation aspects of HCM in government agencies (CIPS, 2006). However, this framework is easy to extend. Based on the structure of the model, one could expand the CIPS framework by introducing new components (for example, training and education) and creating new matrices for them similar to that shown in Figure 13.

**c. GAO Strategic Human Capital Management Model**

In 2002, the GAO published its proposed model for strategic management of human capital, which, along with People CMM, served as a precursor to the CIPS HCM Framework. Like the previous models, the purpose is to provide management, again in this case government agency leadership, a tool for more consistent and effective management of their human capital (GAO, 2002).

The model is based on two principles: the idea that people are assets whose value constitutes an investment and that any framework to manage human capital should be aligned and assessed in terms of the organization's strategic goals. With this focus in mind, the GAO organized its approach around four "Human Capital Cornerstones" and eight "Critical Success Factors," as shown in Figure 16. This configuration is based upon prior GAO studies that indicated these factors as high-risk areas for human capital within the federal government (GAO, 2002).

As in the prior frameworks, the model is based on a capability maturity notion; although the GAO condenses the model further, using only three levels instead of the standard five (see Figure 17). Essentially, Level 1 in this model aligns directly with Maturity Level 1 of the People CMM. A Level 1 agency is not likely to manage its human capital in accordance with the two main principles. Level 2 represents an agency that is working to implement the main principles. Level 3, which corresponds to Maturity Level 5 in the People CMM, is used to describe an agency that has integrated these principles into its everyday activities and can show results that prove the degree of application of effective human capital practices (GAO, 2002).



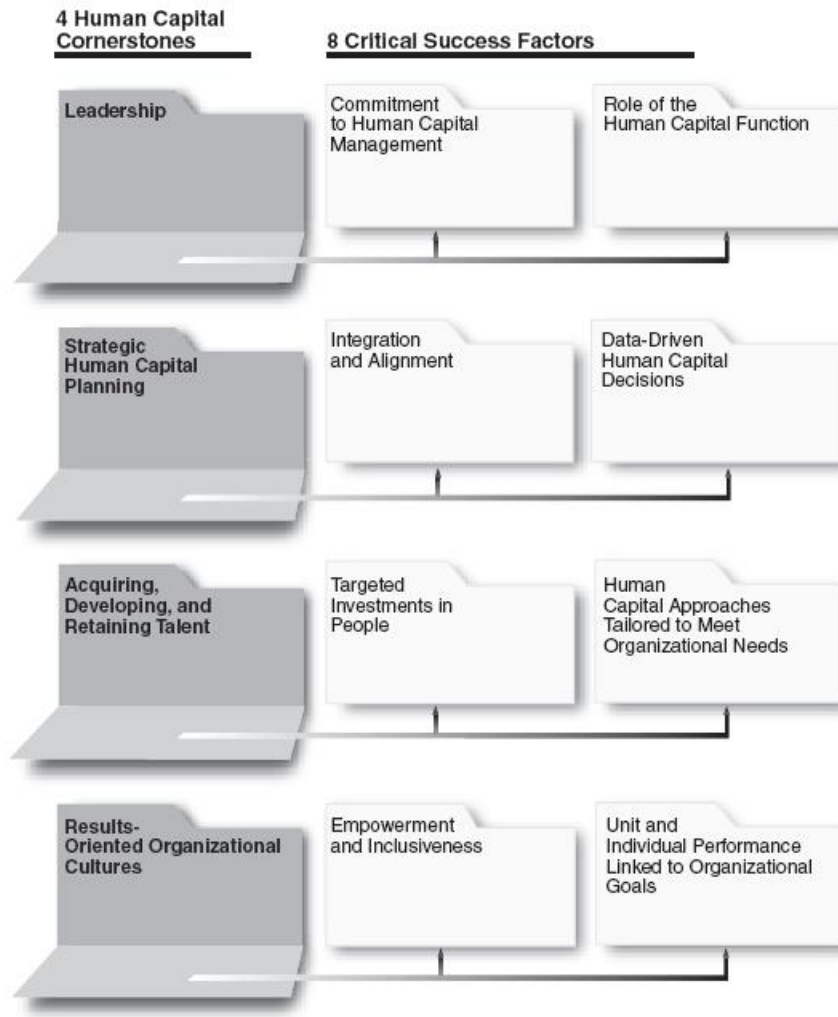


Figure 16. GAO Strategic Human Capital Management Framework Cornerstones and Critical Success Factors Structure (From GAO, 2002)



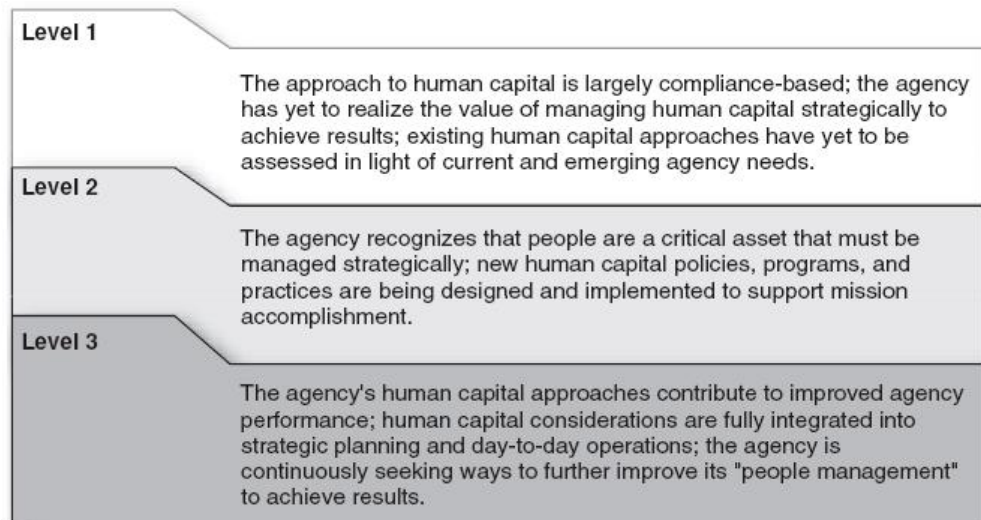


Figure 17. GAO Strategic Human Capital Management Maturity Levels (From GAO, 2002)

As with the CIPS HCM Framework, the GAO describes in detail the qualities of an organization at each level of maturity with respect to each of the eight critical success factors. Table 2 presents a representative example. The complete model is shown in Appendix B (GAO, 2002).

By comparison with both the People CMM and CIPS HCM Frameworks, the GAO is much simpler. The GAO model is not a prescription for addressing human capital management, but rather brings to attention the important elements that an organization should consider when embarking on a human capital improvement program. However, like the prior examples, it demonstrates the wide application of the capability maturity concept as a means to develop and manage human capital.

Regardless of the specific model, it is important to understand that an organization, whether it is a private industry or a government agency, does not become an effective human capital manager overnight. Human capital initiatives require a significant effort by both management and the employees to

transform the organization, or, in the GAO's words: "Maximizing the value of human capital is function not just of specific actions but of cultural transformation" (GAO, 2002, p. 14).

Human Capital Cornerstone	Critical Success Factor	Level 1	Level 2	Level 3
Strategic Human Capital Planning	Integration & Alignment	The agency has yet to fully recognize the link between its human capital approaches and objectives. Existing human capital approaches have yet to be assessed in light of current and emerging agency needs. The agency changes or adopts human capital approaches without considering how well they support organizational goals and strategies, or how these approaches may be interrelated.	The agency's human capital needs are considered during strategic and annual planning. Existing human capital approaches have been assessed for their alignment with current and emerging needs. New human capital initiatives are in design or implementation specifically to support programmatic goals. These initiatives are building towards a coherent, results-oriented human capital program.	The agency's human capital approaches demonstrably support organizational performance objectives. The agency considers further human capital initiatives or refinements in light of both changing organizational needs and the demonstrated successes or shortcomings of its human capital efforts. The human capital needs of the organization and new initiatives or refinements to existing human capital approaches are reflected in strategic workforce planning documents.

Table 2. Example of GAO Strategic HCM Critical Success Factors (After GAO, 2002)

## E. CHAPTER SUMMARY

This chapter discussed the idea of human capital and its importance to organizational effectiveness. Engineering organizations are systems, of which the humans within them, and the means by which they are managed, are primary components. Human capital refers to the economic value derived from the knowledge, skills, and abilities (i.e., competencies) possessed by the organization's people. Human capital creates more value than physical capital and is a strategic asset to the organization.

The means by which firms manage their human capital is most effective when it is aligned with the organization's strategic goals. The firm's human capital, based on its unique knowledge and competencies, gives the firm a competitive edge, differentiates it from its competitors and, due to its intangible nature, is hard to duplicate or buy. The firm's human capital management

structures facilitate the creation of value within the organization and its products through the effective employment of these unique skills.

As exhibited in the four-quadrant models discussed above, every organization contains a mixture of human capital types and manages each type in different ways. In general, the firm is faced with the decision to develop its human capital internally or to acquire it on the market. The mixture of human capital will vary depending on the firm's strategic needs and risks. Typically, firms endeavor to enhance their competitiveness by maximizing the amount of high value unique human capital in the upper right quadrant and enhancing the uniqueness or value of the human capital residing in the other quadrants. However, the external environment can change the conditions that form the basis for the established human capital configuration. If the firm does not continually monitor the environment and adjust the configuration, it risks loss of competitiveness as its human capital decays in value, uniqueness, or both.

Not all firms are adept at managing their human capital, and most do not become so overnight. Frameworks such as the People CMM have been developed to facilitate a firm's evolution from low maturity levels, consisting of ad hoc human capital practices, to high maturity levels in which the firm maximizes the use of its critical human assets and seeks to improve them continuously. This has been tailored for use by organizations in both government and industry as a means to manage human capital more effectively and prevent its decay due to external and internal influences.

In the next chapter, the discussion turns to how these concepts affect the key stakeholders in the shipbuilding industry and DoD. The priorities of these stakeholders will reveal the human capital management needs within the industry. The derived needs will be used subsequently to conduct gap and functional analyses.

### **III. STAKEHOLDER ANALYSIS**

#### **A. INTRODUCTION**

This chapter focuses on the concepts “Stakeholders” and “Stakeholder Analysis” and examines how to apply each concept in the development of a HCM Architecture. The chapter gives a brief discussion of the two concepts, discusses the steps involved in stakeholder analysis, performs a top-level analysis, and in the last step develops the data needed to conduct the Gap Analysis performed in Chapter IV. Stakeholder Analysis is a critical step in the Systems Engineering process. It forms the backbone for developing and managing system requirements and thus has a significant impact to the system architecture.

##### **1. Definition of Stakeholder**

The first concept this chapter will examine is the notion of “Stakeholder” and how to define it. As seen below, the definition of stakeholder varies between academia, government and industry. From the academic perspective, as described by Naval Postgraduate School Professor (NPS) Gary Langford (2007a):

A stakeholder of a system is most typically an entity (a person either acting alone or representing an organization) who can influence the functions, performance, quality, or investment in that system (p. 2).

From the industry perspective, specifically the International Council on Systems Engineering (INCOSE) (2006), a stakeholder is:

A party having a right, share or claim in a system or in its possession of characteristics that meet that party’s needs and expectations (Appendix C, p. 8)

According to one government definition, as given in the Naval Systems Engineering Guide (2004), a stakeholder consists of:

An enterprise, organization, or individual having an interest or a stake in the outcome of the engineering of a system (Department of the Navy [DON], p. 170).

The final definition is a perspective from outside the engineering and government sectors. Schmeer (1999) defines process stakeholders from the health sector point of view as "...actors (persons or organizations) with a vested interest in the policy being promoted" (p. 4).

Some of the common elements from these definitions are:

- The stakeholder has an interest in the system under development.
- The stakeholder can provide some insight into the system under development.
- The stakeholder can influence the development of the system.
- The stakeholder has an interest in the outcome of the system under development.

From these common characteristics, the sheer number of potential stakeholders that can influence system development can be quite large. Therefore, instead of posing the question "Who should be considered a stakeholder for a system?" a more pertinent question is "Who should *not* be considered a stakeholder for a particular system?"

## **2. Definition of Stakeholder Analysis**

With the definition of Stakeholders established, the next step is to define "Stakeholder Analysis." It would seem natural that by definition, Stakeholder Analysis would be an examination of the stakeholders. However, this may not be as obvious as initially thought. Instead, one could ask the question, "What would this examination entail?" Langford (2007a) defines Stakeholder Analysis as "a methodology for identifying stakeholders and analyzing their underlying value and interests in the System" (p. 2). Likewise, Schmeer defines Stakeholder analysis as "...a process of systematically gathering and analyzing qualitative

information to determine whose interests should be taken into account when developing and/or implementing a policy or program” (1999, p. 4).

Consequently, Stakeholder Analysis is not just an examination of the individual stakeholders, but also of how their motives, interests, and values affect system development. In conducting a stakeholder analysis, a clear purpose must be defined in the beginning or the analysis could lose focus and direction resulting from the large quantity of stakeholder inputs. To ensure the analysis does not drift off course, a reference point is required. Table 3 provides a set of guiding statements based on the works of Langford and Schmeer that may be used as a reference point for conducting the analysis and as direction for accomplishing a stakeholder analysis.

Provides a better appreciation of the complexity of the System and the undertaking effort necessary to develop it (Langford, 2007a)
Provides a understanding of the stakeholder influence(s) and how to manage those influences (Langford, 2007a)
Provides a more thorough examination of multiple use objectives (Langford, 2007a)
Provides identification and resolution of potentially conflicting requirements (Langford, 2007a)
Provides exploration of architecture alternatives (Langford, 2007a)
Encourages a forum to improve mutual understanding about issues, ideas, and solutions that might encumber the patience of a smaller, less representative group (Langford, 2007a)
Identities the key actors and assess their knowledge, interests, positions, alliances, and importance related to the system (Schmeer, 1999)
Provides means to detect and act to prevent potential misunderstandings about and/or opposition to the system (Schmeer, 1999)

Table 3. Purposes of Stakeholder Analysis (After Langford, 2007a; Schmeer, 1999)

## **B. STAKEHOLDER ANALYSIS PROCESS**

Before discussing the inputs and results of the stakeholder analysis, a brief overview of the steps involved is necessary. There are five major steps in stakeholder analysis, derived based on Langford (2007a) as follows: (1) identification of potential stakeholders; (2) classification of potential stakeholders; (3) determination of potential stakeholder and system relationships; (4) determination of key system stakeholders; and (5) definition of stakeholder requirements. The following sections describe these steps.

### **1. Identification of Potential Stakeholders**

According to Schmeer (1999), the “[identification of] potential stakeholders is extremely important to the success of the Stakeholder analysis” (p. 2-6). By compiling an extensive list of potential stakeholders, the analysis can leverage the list to determine the key stakeholders that exercise the greatest influence on the system’s development. The first stage in the identification of potential stakeholders is to conduct a brainstorming session. In this session, a “mind-dump” of all potential stakeholders that can be contemplated is documented. Or, in Langford’s (2007a) words, “Stakeholders Analysis begins with a brain-storming [sic] session that lets you write down all you think you know. [It is] a process to remove the ‘junk’ from your head” (p. 16).

The next stage in the identification process is the creation of scenarios that require potential stakeholder interactions. These scenarios may help identify additional stakeholders overlooked during the initial brainstorming session. The scenarios should involve aspects of the system under development. Each scenario is then adapted using events that give rise to the reason behind the scenario. These adaptations take the form of parameter changes related to timing, location, participants, or other pertinent factors that alter the assumptions or initial conditions. Additionally, the analyst explores alternatives in the scenarios based on “what-if” situations that represent different courses of action

(i.e., different choices). Each adaptation will drive a different system response. By examining the different responses from these variations, one will observe (or in some cases, discover) the stakeholders that interact with the system (Langford, 2007a).

Finally, a master list of potential stakeholders is compiled from the results of the brainstorming session, augmented with the lists generated from examination of the scenarios.

## **2. Classification of Potential Stakeholders**

Classification of potential stakeholders proceeds using the following steps: (1) determination of the system boundaries, (2) classification of potential internal stakeholders, (3) classification of potential first-order stakeholders (4) classification of potential second-order stakeholders and (5) determination of stakeholder worth (Langford, 2007a)

First, to define the system boundary, one must understand that it can be somewhat ephemeral in nature. That is, the incidental interactions between stakeholders, the elements and domains that characterize the system, and external interactions with other systems and stakeholders, will change over time and therefore change the system boundary (Langford, 2007a).

Those stakeholders that interact only with internal system elements or with other stakeholders are classified as internal stakeholders. Those stakeholders that are in direct *contact* with the system, but do not have direct *interaction* with the internal stakeholders are considered first-order stakeholders. Second-order stakeholders are defined as those stakeholders that are connected indirectly to the system via interaction with first-order stakeholders. Both first and second-order stakeholders are classified as boundary stakeholders because they interact with external entities across the system boundary. Therefore, the group of internal and boundary stakeholders comprise the set of valid system stakeholders (Ku, 2007; Langford, 2007a).



After classifying the stakeholders, it is necessary to prioritize them based on the influence they have on the system, in terms of worth. This prioritization is facilitated through application of the Worth Activation Function (WAF) concept. Stakeholders interact with each other at a given time. Energy and data are exchanged at the point of interaction. This transfer consists of behaviors such as cooperation, competition, enhancing, enabling, destruction, or degradation, among others. In this pair-wise interaction, the exchange involves something of worth. That is, something of value (i.e., useful) is received by a stakeholder for the expense of an investment in terms of money or time. The worth of the exchange is based on a judgment by the stakeholder that the value obtained involved an acceptable risk, judged by the potential for loss in terms of quality. Essentially, the exchange has high worth if the risk of lost quality is acceptable to the stakeholder. The WAF is the vehicle through which this exchange is expressed (Langford, 2007a). The WAF and its application in stakeholder classification will be discussed in further detail later in the chapter.

### **3. Determination of Potential Stakeholder and System Relationships**

Determining the relationships between the potential stakeholders and the system is an initial (and critical) step in prioritizing the stakeholders. The purpose for prioritizing the stakeholders ensures vital inputs (stakeholder problems, needs, and requirements) are utilized to develop the functional analysis, and thereafter, the system architecture for the HCM strategy. Drawing from the pool of potential stakeholders established during the previous steps, stakeholders are grouped into different system roles, which assist their prioritization and facilitates selection of appropriate stakeholder inputs.

#### **4. Determination of System Stakeholders**

The next step in the Stakeholder Analysis is the determination of key system stakeholders. Selection criteria are established to reduce the list of potential stakeholders generated from the previous steps to a concentration of stakeholders whose input will have the greatest impact to the system. System impact in this case is measured qualitatively and can be expressed in terms of stakeholder importance and stakeholder influence.

Stakeholder Importance is a qualitative measure based on the product of the number of interactions a stakeholder has with other stakeholders, and the worth of these interactions as determined by the Worth Activation Function (WAF). From the work of Ku (2007), the importance of a stakeholder is based on the number of interactions each stakeholder has with all other stakeholders (internal, external, first-order, etc.). The more direct an interaction a stakeholder has with others within the system, the more likely it is that the stakeholder's actions will affect the whole system rather than individual subcomponents of the system.

Unlike Stakeholder Importance, Stakeholder Influence is a qualitative measure based on the types of relationships the stakeholders have with the system domain (internal, first-order, or second-order) and the duration of these relationships throughout the product's life cycle. The closer a stakeholder is to the system domain, the greater the influence that stakeholder may have over the system. Therefore, internal stakeholders may have greater influence than first-order stakeholders may. In turn, first-order stakeholders may have greater influence than second-order stakeholders may. In addition, the duration of the relationships has a bearing on the stakeholder's influence. If an internal stakeholder only interacts with the system during the concept development phase, but a first-order stakeholder interacts with the system well into the deployment phase, the first-order stakeholder may have a greater influence on

the system than the internal stakeholder may. Both the type and duration of stakeholder and system domain relationships contribute to Stakeholder Influence (Ku, 2007).

The selection of key stakeholders is based on the product of the stakeholder's importance and influence. From these factors, the stakeholders are ranked as primary, secondary and tertiary entities based upon thresholds determined by the analyst(s). Primary stakeholder needs have direct input into development of the system's Functional Analysis (FA) and the Overall Measure of Effectiveness (OMOE) model. Secondary stakeholder inputs have limited weighting in the development of the FA and OMOE. However, these stakeholders will be incorporated to the maximum extent possible within system boundaries, as described in subsequent sections of this chapter. Tertiary stakeholder inputs are considered beyond the scope of this analysis and will not be incorporated into the FA and OMOE.

## **5. Definition of Stakeholder Requirements**

The final step of the Stakeholder Analysis is the definition of stakeholder requirements. This step is closely related to the Stakeholder Requirements Definition Process described in Revision 3 of the INCOSE Handbook, which states: "The purpose of the Stakeholder Requirements Definition Process is to elicit, negotiate, document, and maintain stakeholders' requirements for the system-of-interest within a defined environment" (INCOSE, 2006, p. 4.2).

After identification of the primary, secondary and tertiary stakeholders, problem statements can be developed. Langford (2007b) defines a problem in the following terms: "Whenever there is a difference between what can be done and what you want to do, and you do not know how to achieve the desire, there is a problem" (p. 38). For every stakeholder problem, several stakeholder needs can be identified. A need arises from a condition faced by the stakeholder that requires a solution to alleviate it (Langford, 2007b). For example, a

telecommuter (stakeholder) may have a problem with the speed of their home internet service. Needs derived from this telecommuter's problem could be:

- A need to be more productive associated with their job performance.
- A need to increase career advancement and salary through their job performance.
- A need to secure their child's educational future by increasing monetary contributions to the child's educational fund through increased salary.
- A need to plan for their child's future success.

Once stakeholder needs have been documented, they are used to derive stakeholder requirements, which are essential for guiding system development and serve to frame the project scope (INCOSE, 2006). These requirements drive the development of the FA, OMOE and system architecture. In addition, the stakeholder requirements are used in Gap Analysis to determine the desired state sought by the stakeholder ("where we want to be") and, in conjunction with the perceived existing state, establish the gaps to be addressed by the system solution.

The remainder of this chapter presents the Stakeholder Analysis; the data used to perform it, discusses the results, and identifies the key insights derived from the analysis.

## **C. STAKEHOLDER ANALYSIS DATA**

In this section, the steps described in the previous section are applied to determine the key stakeholders involved in the development of a system architecture for implementing a HCM strategy for the shipbuilding industry.

### **1. Identification of Potential Stakeholders**

From the brainstorming session conducted as described above, a table listing potential stakeholders was created, categorized into the groups Academia,

Industry, Government, and Other. A portion of this list is presented in Table 4. The full table of 90 stakeholders is presented in Appendix C, Table 24 and Table 25).

Academia	Industry	Government	Other
<ul style="list-style-type: none"> <li>• U.S. Colleges and Universities with accredited undergraduate engineering degree programs</li> <li>• U.S. Colleges and Universities with accredited graduate engineering degree programs</li> <li>• U.S. Technical Colleges and Universities offering associate engineering degree programs</li> <li>• U.S. Colleges and Universities offering specialty naval engineering degree programs</li> </ul>	<ul style="list-style-type: none"> <li>• International Council On Systems Engineering (INCOSE)</li> <li>• International Organization for Standardization (ISO)</li> <li>• International Engineering Consortium (IEC)</li> <li>• Institute of Electrical and Electronics Engineers (IEEE)</li> <li>• American Society of Naval Engineers (ASNE)</li> <li>• Electronic Industries Alliance</li> <li>• Society of Naval Architects and Marine Engineers (SNAME)</li> <li>• General Dynamics Shipyards</li> <li>• Northrop Grumman Shipyards</li> <li>• U.S. Shipyard Management</li> <li>• American Bureau of Shipping (ABS)</li> <li>• Center for Innovation In Ship Design</li> </ul>	<ul style="list-style-type: none"> <li>• Navy Program Executive Offices (PEOs)</li> <li>• Navy Program Management Ship (PMS)</li> <li>• Naval Sea Systems Command (NAVSEA)</li> <li>• Electric Ship Office (ESO)</li> <li>• Department of the Navy (DoN)</li> <li>• Naval Supply Systems Command (NAVSUP)</li> <li>• Office of Chief of Naval Operations (CNO)</li> <li>• Environment and Sustainable Development Research Center (ESDRC)</li> <li>• Office of Naval Research (ONR)</li> <li>• National Shipbuilding Research Program (NSRP)</li> <li>• Defense Acquisition University (DAU)</li> <li>• Naval Air Systems Command (NAVAIR)</li> <li>• U.S. Coast Guard and associated entities</li> <li>• Department of Homeland Security</li> </ul>	<ul style="list-style-type: none"> <li>• Taxpayers</li> <li>• Students</li> <li>• Professors</li> <li>• Teachers</li> <li>• Administrators</li> <li>• Employees</li> <li>• Uniformed Service Personnel</li> <li>• Ship Buyers</li> <li>• Families of users</li> <li>• Churches</li> <li>• Civic organizations</li> <li>• Investors</li> <li>• Families of shipyard workers</li> <li>• Families of civil service engineers</li> <li>• Communities</li> </ul>

Table 4. Representative Stakeholders Determined During Brainstorming

Next, four scenarios were created to expand the list in Table 4. with stakeholders that may have been overlooked in the brainstorming session. A brief description of each scenario is given, followed by a representative list of associated potential stakeholders.

Scenario 1 - Creation of the Next Generation Integrated Power System Handbook:

The Electric Ship Office (ESO), a division of the Naval Sea Systems Command (NAVSEA), requests that a team be created consisting of individuals from all major US shipyards responsible for developing a concept level design of a generic Integrated Power Systems (IPS). This generic IPS could be applied to all near future (within the next 10 years) and future-future (within the next 30 years) Navy platforms. Team members are required to have the educational and professional backgrounds necessary to produce concept-level design products in association with the task requested by ESO (Doerry, 2007).

A sampling of potential stakeholders associated with this scenario is presented in Table 5, with a full presentation in Appendix C, Table 26).

Academia	Industry	Government	Other
<ul style="list-style-type: none"> <li>• U.S. Colleges and Universities with accredited undergraduate engineering degree programs</li> <li>• U.S. Colleges and Universities with accredited graduate engineering degree programs</li> <li>• U.S. Technical Colleges and Universities offering associate engineering degree programs</li> <li>• U.S. Colleges and Universities offering specialty naval engineering degree programs</li> </ul>	<ul style="list-style-type: none"> <li>• INCOSE</li> <li>• ISO</li> <li>• IEC</li> <li>• IEEE</li> <li>• ASNE</li> <li>• ANSI</li> <li>• General Dynamics Shipyards</li> <li>• Northrop Grumman Shipyards</li> <li>• U.S. Shipyard Management</li> <li>• ABS</li> </ul>	<ul style="list-style-type: none"> <li>• Navy PEO organizations</li> <li>• Navy PMS organizations</li> <li>• NAVSEA</li> <li>• ESO</li> <li>• DoN</li> <li>• Naval Supply Systems Command (NAVSUP)</li> <li>• CNO</li> <li>• ESDRC</li> <li>• ONR</li> </ul>	<ul style="list-style-type: none"> <li>• Taxpayers</li> <li>• Students</li> <li>• Professors</li> <li>• Teachers</li> <li>• Administrators</li> <li>• Employees</li> <li>• Uniformed Service Personnel</li> <li>• Ship Buyers</li> </ul>

Table 5. Representative Stakeholders Determined Examination of Scenario  
1

## Scenario 2 - Creation of a collegiate shipbuilding curriculum:

The National Shipbuilding Research Program (NSRP) has proposed to develop a shipbuilding curriculum at the collegiate level to foster and enhance the shipbuilding skills of the current and future workforce. The goal is to produce ship designers that have capabilities beyond those of CAD operators by developing a curriculum that will produce engineers with the discipline-specific background and training that will make them more effective upon entry to the industry (National Shipbuilding Research Program Advanced Shipbuilding Enterprise [NSRP ASE], 2008a).

A sampling of potential stakeholders associated with this scenario is presented in Table 6, with a full presentation in Appendix C, Table 27).

Academia*	Industry	Government	Other
<ul style="list-style-type: none"> <li>University of Wisconsin-Marquette</li> <li>University of South Alabama</li> </ul> <p>* The NSRP program states these universities as the only academic participants in the collegiate shipbuilding program.</p>	<ul style="list-style-type: none"> <li>Bender Shipbuilding and Repair</li> <li>Bollinger Shipyards</li> <li>Northrop Grumman Shipbuilding-Gulf Coast</li> <li>Genoa Design International</li> <li>Gibbs &amp; Cox, Murray Associates</li> <li>Shipbuilding Design Software Developers</li> </ul>	<ul style="list-style-type: none"> <li>Local city, county, and state government entities</li> <li>Navy PEO organizations</li> <li>NSRP</li> <li>Navy PMS organizations</li> <li>OSD</li> <li>U.S. Congress</li> <li>United States Marine Corps (USMC)</li> <li>DoN</li> </ul>	<ul style="list-style-type: none"> <li>Taxpayers</li> <li>Students</li> <li>Professors</li> <li>Teachers</li> <li>Administrators</li> <li>Parents</li> <li>Investors</li> <li>Communities</li> </ul>

Table 6. Representative Stakeholders Determined Examination of Scenario 2

## Scenario 3 - Shipbuilding Career Day Events:

NSRP has proposed to encourage middle and high school students to consider careers in the shipbuilding industry.

The Shipbuilding Career Days project will conduct a series of daylong workshops and classes in which students can learn about careers in the shipbuilding and repair industry. This program

focuses on middle and high school students and addresses the issue of raising the awareness among students of the career opportunities available in the shipbuilding and repair industry while promoting a positive image of the industry among students and the community (NSRP ASE, 2008b).

A sampling of potential stakeholders associated with this scenario is presented in Table 7, with a full presentation in Appendix C, Table 28).

Academia*	Industry	Government	Other
<ul style="list-style-type: none"> <li>Old Dominion University</li> </ul> <p>* The NSRP program states this university as the only academic participant in the Career Days program.</p>	<ul style="list-style-type: none"> <li>Northrop Grumman Shipbuilding-Newport News</li> <li>Northrop Grumman Shipbuilding-Gulf Coast</li> <li>Colonna's Shipyard</li> <li>Shipyard Management</li> <li>Recruiting Agencies</li> </ul>	<ul style="list-style-type: none"> <li>Local city, county, and state government entities</li> <li>Navy PEO organizations (all types)</li> <li>NSRP</li> <li>Navy PMS organizations</li> <li>OSD</li> <li>U.S. Congress</li> <li>USMC</li> <li>DoN</li> </ul>	<ul style="list-style-type: none"> <li>Taxpayers</li> <li>Students</li> <li>Professors</li> <li>Teachers</li> <li>Administrators</li> <li>Parents</li> <li>Churches</li> <li>Civic Organizations</li> <li>Communities</li> </ul>

Table 7. Representative Stakeholders Determined Examination of Scenario

3

Scenario 4 - Post Katrina Human Capital Management Plans to support current shipbuilding production schedules:

Some Gulf Coast shipyards have faced a number of threats to maintaining workforce capabilities. A mass exodus of individuals from the area after the hurricane has limited the number candidates to fill job positions. Community limitations on resources such as homeowner's insurance have escalated the reluctance of individuals to consider the Gulf Coast area as a place to reside. Factors such as these have had an impact on the capability of these shipyards to met pre-Katrina construction schedules. To help mitigate this phenomenon, some of these shipyards are in the process of developing Human Capital Management Plans that could help ensure production schedules are met (Bennet, 2007; "Northrop Grumman's President," 2007, "Northrop Sailing," 2005).



A sampling of potential stakeholders associated with this scenario is presented in Table 8, with a full presentation in Appendix C, Table 29).

Academia	Industry	Government	Other
<ul style="list-style-type: none"> <li>• Jackson County Mississippi School System</li> <li>• George County Mississippi School System</li> <li>• Harrison County Mississippi School System</li> <li>• Mobile County Alabama School System</li> <li>• Jefferson Parish Louisiana School System</li> <li>• Naval Postgraduate School</li> <li>• Virginia Polytechnic Institute</li> <li>• Texas A&amp;M University</li> <li>• University of Maryland</li> <li>• Stephens Institute</li> <li>• Pennsylvania State University</li> <li>• University of New Orleans</li> <li>• University of South Alabama</li> <li>• Jackson State University</li> <li>• Mississippi State University</li> <li>• University of Southern Mississippi</li> </ul>	<ul style="list-style-type: none"> <li>• INCOSE</li> <li>• IEEE</li> <li>• ASNE</li> <li>• SNAME</li> <li>• Northrop Grumman Shipbuilding-Gulf Coast</li> <li>• Recruiting Agencies</li> <li>• ABS</li> <li>• American Shipbuilding Association</li> <li>• American Society of Mechanical Engineers (ASME)</li> <li>• American Society of Civil Engineers (ASCE)</li> </ul>	<ul style="list-style-type: none"> <li>• Jackson, George, and Harrison County (Mississippi) government entities</li> <li>• Mobile County Alabama government entities</li> <li>• Jefferson Parish Louisiana government entities</li> <li>• Navy PEO organizations</li> <li>• NSRP</li> <li>• NAVSEA</li> <li>• State government entities from Alabama, Louisiana, and Mississippi</li> <li>• U.S. Congress</li> <li>• DoD</li> <li>• OSD</li> <li>• Department of Homeland Security</li> <li>• U.S. Department of Education</li> </ul>	<ul style="list-style-type: none"> <li>• Taxpayers</li> <li>• Students</li> <li>• University Professors</li> <li>• Teachers</li> <li>• Administrators</li> <li>• Employees</li> <li>• Parents</li> <li>• Churches</li> <li>• Civic Organizations</li> <li>• Communities</li> </ul>

Table 8. Representative Stakeholders Determined Examination of Scenario 4

The lists of potential stakeholders from the brainstorming session and scenarios were combined into one master list of 134 potential stakeholders that were initially considered as concerned in some aspect with human capital strategies in the shipbuilding industry, which is shown in Appendix D, Table 30 through Table 33.

## **2. Classification of Potential Stakeholders**

As discussed above, the initial stage of the classification of potential stakeholders is the determination of the system boundary. Listed below are the system boundaries associated with the problem of HCM strategy within the shipbuilding industry:

- Academic boundaries
  - Colleges/Universities associated with Gulf Coast\* shipyards that offer engineering degrees
  - Primary and secondary educational systems associated with Gulf Coast shipyards
- Industry boundaries
  - Shipbuilding Industry
  - Industries that support shipbuilding
- Government boundaries
  - Government entities related to the shipbuilding industry
- Engineering and related disciplines boundaries
  - Mechanical Engineering
  - Electrical Engineering
  - Civil Engineering
  - Industrial Engineering
  - System Engineering
  - Computer Engineering
  - Naval Architecture

Based on these boundaries and the list of potential stakeholders, each stakeholder is classified as internal, first-order or second-order (see sample in

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\* Author's Note: The choice of boundaries defined by Gulf Coast shipyards is based on the authors' personal experience in that segment of the shipbuilding industry. Future studies could expand this boundary to tailor the analysis for either specific segments or wider applicability.

Table 9). (Note: Throughout this presentation, representative samples are given to illustrate the analysis. The reader is referred to Appendix D for presentation of the full analysis).

Stakeholder Category	Potential Stakeholders	Internal					First-Order			Second-Order		
		Designers	Builders	Participants	Suppliers	System Providers	User	Adversaries	System Supporters	Customers	Competitors	Investors
Academia	Naval Postgraduate School	X										

Table 9. Stakeholder Analysis: Classification of Stakeholders

### 3. Determination of Potential Stakeholder and System Relationships

In this step, each stakeholder is analyzed to determine their interactions with the system and with the other stakeholders. First, an evaluation of the product life cycle stages affected by each stakeholder are documented, as shown in Table 10. Each stakeholder's impact per life cycle stage is based on the following scale:

- 1 points – Concept Design Stage Influence
- 0.75 points – Preliminary Design Stage Influence
- 0.50 points – Detail Design Stage Influence
- 0.25 points – Production Stage Influence
- 0.25 points – Deployment Stage Influence
- 0.10 points – Disposal Stage Influence

Since the focus of this work is on early stage design of a HCM architecture, the scale is heavily weighted for concept and preliminary stage

stakeholder influences. The determination of the scoring and weighting factors is subjective and based on the writer's knowledge gained through research of this subject matter.

Stakeholder Category	Potential Stakeholders	Product Life Cycle					
		Concept	Preliminary	Detail Design	Production	Deployment	Disposal
Academia	Naval Postgraduate School	1.00	0.75	0.50	0.25	0.25	0.10

Table 10. Stakeholder Analysis: Stakeholder Impacts to System Lifecycle Stages

Next, a stakeholder worth matrix is developed to measure the stakeholder interactions. The Worth Activation Function (WAF), as defined by Langford (2007a) is used to characterize stakeholder interactions. During system design, various stakeholders exert their importance and influence on system elements. However, these stakeholders are themselves elements of the system. The stakeholders and other elements interact with each other on a one-to-one (or in some cases one-to-many) basis. In these interactions, matter, energy and/or information is transferred between stakeholders. One stakeholder receives some measure of worth (something useful or valuable) from another stakeholder. The received worth can be judged based on the investment, risk, or loss accompanying the transaction. Additionally, certain behaviors emerge within the system, which are categorized as either “cooperative, competitive, enhancing, enabling, destructive, or degrading” (p. 3). The WAF, therefore, is the explicit means by which the measure of worth transferred between stakeholders can be captured. Therefore, given the following definitions:

$i$  = initial input

$i + 1$  = the following input

$n$  = final input

$\Delta$  = WAF (exchange of Worth between stakeholders)

and,

Stakeholder <sub>$i$</sub>   $\Delta_i$  Stakeholder <sub>$i+1$</sub>  = Stakeholder <sub>$i+1$</sub>   $\Delta_i$  Stakeholder <sub>$i$</sub>

System Impact <sub>$i$</sub>  = Stakeholder <sub>$i$</sub>   $\Delta_i$  Stakeholder <sub>$i+1$</sub>

System Impact <sub>$i+1$</sub>  = Stakeholder <sub>$i+1$</sub>   $\Delta_{i+1}$  Stakeholder <sub>$i+2$</sub>

M

System Impact <sub>$n$</sub>  = Stakeholder <sub>$n$</sub>   $\Delta_n$  Stakeholder <sub>$n-1$</sub>

if the exchange of worth between Stakeholder <sub>$i+1$</sub>  and Stakeholder <sub>$i+2$</sub>  ( $\Delta_{i+1}$ ) is greater than the exchange of worth between Stakeholder <sub>$n$</sub>  and Stakeholder <sub>$n-1$</sub>  ( $\Delta_n$ ), the system impact of  $\Delta_{i+1}$  is greater than  $\Delta_n$ . As a result, the interaction between Stakeholder <sub>$i+1$</sub>  and Stakeholder <sub>$i+2$</sub>  has a greater priority to the system than the interaction of Stakeholder <sub>$n$</sub>  and Stakeholder <sub>$n-1$</sub> . For this stakeholder analysis, each of these stakeholder interactions is graded according to the following scale.

- 9 points – High level of impact based on the system boundaries
- 4 points – Medium level of impact based on the system boundaries
- 1 points – Low level of impact based on the system boundaries

The determination of these weighting factors is subjective and based on knowledge gained by the authors during research on this subject matter. A representative depiction of the application of this grading to determine stakeholder classification based on worth is shown in Table 11.

Stakeholder Category	Potential Stakeholders	Stakeholder Worth Matrix	Industry					
			Stakeholder # 31	Stakeholder # 32	Stakeholder # 33	Stakeholder # 38	Stakeholder # 39	Stakeholder # 40
Academia	Naval Postgraduate School	Stakeholder # 14	1	4	4	4	1	9

Table 11. Stakeholder Analysis: Determination of Stakeholder Worth

Once the stakeholder WAF values are determined, stakeholder importance and stakeholder influence are calculated. As previously discussed, stakeholder importance is the product of the number of interactions a stakeholder has with other stakeholders and the total worth of these interactions, as shown in Table 12.

Stakeholder Category	Potential Stakeholders	Importance		
		Number of Interactions	Worth of Interactions	Total Level of Importance
Academia	Naval Postgraduate School	39	70	2730

Table 12. Stakeholder Analysis: Determination of Stakeholder Importance

Stakeholder influence is the product of the type of relationship stakeholder has with the system and the duration of these relationships throughout the product life cycle. Each type of relationship is graded based on the following scale.

- 9 points – Internal relationships
- 4 points – First-order relationships
- 1 points – Second-order relationships

The duration in life cycle is calculated as the sum of the weightings from the determination of stakeholder impacts for each life cycle stage shown, as shown above in Table 10. Table 13 shows an example of the stakeholder influence calculation.

Stakeholder Category	Potential Stakeholders	Influence		
		Relationship Type	Duration in Life Cycle	Total Level of Influence
Academia	Naval Postgraduate School	9	2.85	25.65

Table 13. Stakeholder Analysis: Determination of Stakeholder Influence

Based on the value of the product of stakeholder importance and stakeholder influence a stakeholder is classified as a primary, secondary or tertiary stakeholder. In this scoring, the notional thresholds for determining stakeholder classification are defined as follows, again, based on the subjective judgment and knowledge gained by the authors during research:

- Primary Stakeholder – Stakeholder importance x Stakeholder influence > 75,000
- Secondary Stakeholder – 75,000 > Stakeholder importance x Stakeholder influence > 15,000
- Tertiary Stakeholder – Stakeholder importance x Stakeholder influence < 15,000

Table 14 provides an example of the application of these thresholds to determine stakeholder classification.

Stakeholder Category	Potential Stakeholders	Total Stakeholder Worth	Stakeholder Classification		
			Primary?	Secondary?	Tertiary?
Academia	Naval Postgraduate School	70024.5	Yes	No	No

Table 14. Stakeholder Analysis: Classification of Stakeholders

#### 4. Determination of System Stakeholders

Based on the scoring and classification performed in the previous step, a list of the primary and secondary stakeholders that influence the development of a HCM strategy for the shipbuilding industry was generated, as presented in Table 15 and Table 16, respectively.

Primary Stakeholders
Naval Postgraduate School
U.S. Shipyard Management
Northrop Grumman Shipbuilding-Gulf Coast
American Shipbuilding Association
National Shipbuilding Research Program (NSRP)
Department of the Navy
Naval Sea Systems Command (NAVSEA) and all associated groups

Table 15. List of Primary Stakeholders

Secondary Stakeholders
Recruiting agencies
American Bureau of Shipping
Northrop Grumman Newport News
PEO (Program Executive Office) all associated groups
PMS all associated groups
ESO - Electric Ship Office
Office of the Chief of Naval Operations

Table 16. List of Secondary Stakeholders



## **5. Defining Stakeholder Requirements**

Based on the inputs of the primary and secondary stakeholders, the following is a summary of generalized problem statements developed associated with Human Capital Management as it relates to the science and engineering fields in the shipbuilding industry. A complete list of specific problems statements is listed in Appendix E, Table 48.

- The production and schedule rates for ship design and construction affect industry employment capabilities.
  - Limits recruiting capabilities
  - Limits or increases learning curve
  - Perishable, highly skilled workforce in a low-rate production environment is difficult to maintain
- Naval ship design is complex, stochastic, labor extensive and requires individuals with specialized skills.
  - Limited dedicated industry resources due to stochastic nature (research, faculty, etc.)
  - Reluctant to invest money into these resources due to stochastic nature
  - Naval engineering skills are specialized and not particular in other industries
- Awareness of opportunities in naval engineering and related fields is limited.
  - The field is broad but the number of students is limited
  - Faculty and students seems unaware of industry benefits and resources
- Interaction between university and industry entities is low.
- Competition for students for naval engineering and related fields is heavy.
  - Computer science, medical and other fields offer students other advantages such as higher pay, more job opportunities, more areas for exciting research, etc.
  - Maintaining a pool of potential innovative students is key to the health of the industry
- There is difficulty in replacing older, experienced workers with younger workers.

- Lack of mentoring of younger workers
- Lack of knowledge transfer from older workers to younger workers
- Knowledge transfer rate between older workers and younger workers is too slow

Based on the generalized stakeholder problems, a list of needs associated with Human Capital Management related to science and engineering fields in the shipbuilding industry has been compiled in Appendix E, Table 48. The top-level stakeholder requirements associated with these needs are as follows:

The HCM Architecture shall:

- Enhance the ability of shipbuilders to retain and maintain technical workforce expertise in a low-rate production environment
- Encourage university and secondary educational entities to promote awareness of opportunities in the shipbuilding technical industry
- Promote the development of curricula at the university level associated with naval engineering and related fields
- Promote the increase of industry resources needed to recruit, train and maintain a complete technical workforce
- Facilitate the transfer of industry specific technical knowledge between industry entities and the industry workforce
- Facilitate a means for technical knowledge capture
- Enhance the ability of industry, government and academic entities to promote innovation and advancements in the technical shipbuilding community
- Encourage students at the university and secondary educational level to consider naval engineering and related fields as viable career options
- Enhance technical job growth in the industry in order to compete with other fields such as Computer Science and Medicine
- Encourage the increase of technical worth of the current industry workforce

The statements listed above are not requirements as traditionally defined in Systems Engineering. They are guidelines that should be used to develop an organization's specific top-level requirements for their HCM architecture. Since each organization's HCM needs are different, specific top-level requirements must be developed to cater to a given stakeholder's needs. Thus, these guidelines can be used to help system developers ensure that the top-level requirements they develop for their specific HCM architecture link back to the overall HCM needs of the shipbuilding industry. Therefore, every time the term "requirements" is used hereafter, it refers to a *guideline* philosophy for requirements development rather than traditionally defined requirements.

#### **D. CHAPTER SUMMARY**

The purpose of this chapter was to provide the reader with a background understanding of stakeholders and stakeholder analysis specific to technical and engineering human capital within the shipbuilding industry. Readers should understand what a stakeholder is, the steps in performing a stakeholder analysis, and how these steps were implemented in the analysis discussed above. Figure 18. gives a conceptual depiction of how the ingredients of the analysis will be combined to form the backbone of the Functional Analysis and Overall Measure of Effectiveness Model discussed later in Chapter V.

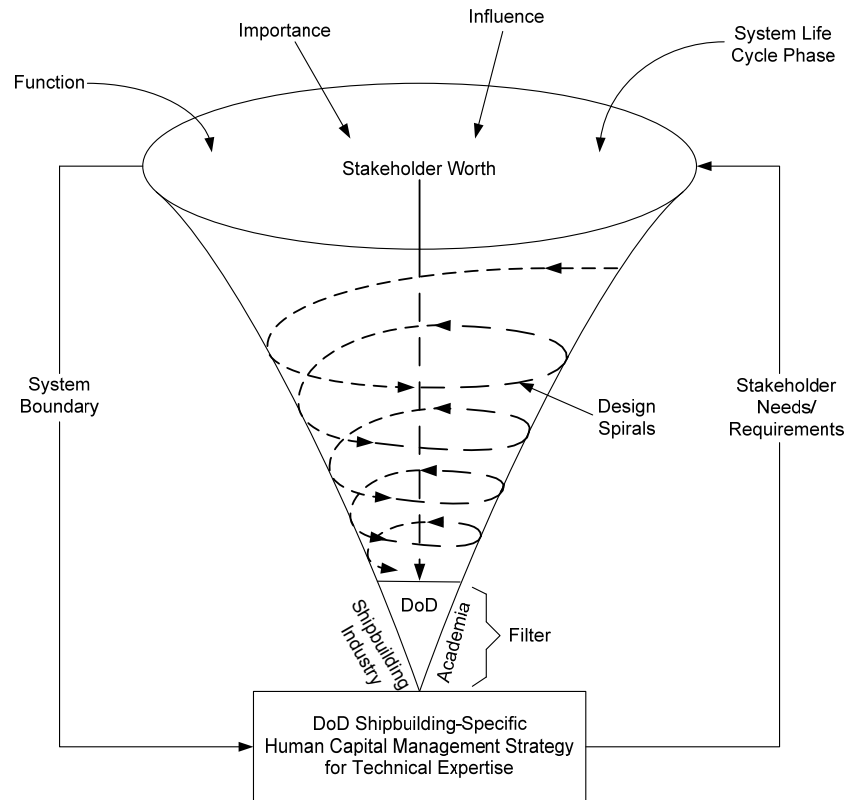


Figure 18. Generic Depiction of How Stakeholder Analysis Feeds Development of the System Architecture

The depiction in Figure 18, gives the reader a conceptual overview of how the contents of this chapter are integrated into a Human Capital Management Architecture for developing technical expertise in the shipbuilding industry. As can be seen in the figure, the selection of stakeholders, their inputs, importance and influence change as the system transitions through the different stages of the system's life cycle. The data presented in this chapter is for one phase of the life cycle (concept design), and is the first initiation of many that should be performed to capture vital stakeholder information.

The methodology used in this chapter revolves around the importance of gathering stakeholder inputs. Without proper identification of stakeholders and the gathering and prioritization of their inputs, system development and implementation would become chaotic at best, and the developmental cost

(compared to initial estimates) could be astronomical. For example, through the implementation of this stakeholder analysis, a listing of 134 potential stakeholders is identified. From this listing, only seven primary and seven secondary stakeholders were considered to have substantial importance and influence on the system during concept level design. Hence, without proper focus provided by such a stakeholder investigation, system development becomes a difficult undertaking with high levels of cost, schedule and performance risks. The results from this chapter will be used to facilitate development of Chapters IV (Gap Analysis) and V (Functional Analysis).

## **IV. GAP ANALYSIS: ASSESSING HUMAN CAPITAL GAPS IN THE SHIPBUILDING INDUSTRY**

### **A. GAP ANALYSIS THEORY**

Before examining gaps in shipbuilding industry human capital strategies, it is helpful to understand the nature of gaps, how they are perceived, and the methods employed for analyzing and closing them. The analysis will be guided using the Enterprise Framework model for Gap Analysis developed by Langford, Franck, Huynh, & Lewis (2007), and accomplished by applying a gap matrix in the fashion described by The Open Group (1999), as described in the following sections.

#### **1. Gaps and Gap Analysis Defined**

Gaps are defined by a difference in what one has in relation to what one desires or needs and are framed by a notion (or measurement) of a shortcoming or difference in something valued or important compared to one's expectations. Critical to the definition of a gap are the starting and ending points (the existing condition, state, or level of performance and the corresponding desired condition, state, or level of performance, respectively) and a characterization of what makes these points different. Gap Analysis is the method used to analyze the perceived difference (the gap) and explore the means for closing it. This analysis is not driven temporally, dictating only that the given events *will* happen rather than *when* they will happen. Instead, the concern is the difference between the present and future states and the development of the means by which the decision-maker can change the present reality to the desired future reality. Gap analysis provides a means for the decision-maker to evaluate alternatives for closing the gap based on the degree to which they meet stakeholder needs (Langford, et al., 2007).

As Langford, et al. (2007) describe: “The desired results of Gap Analysis are to: (1) predict what we need for a postulated event, (2) compare what we need to what we have, (3) identify those items that need to be changed or added along with the investment in time and money required, and (4) enumerate the potential limitation of future capabilities” (p.19). The tool to facilitate this analysis is the Enterprise Framework model.

## 2. Enterprise Framework Model Metrics

The Enterprise Framework presents the context by which an organization examines its assumptions while facilitating insights into the causes and possible solutions for the perceived gaps. To illustrate this context, the model utilizes the metrics of Value, Worth, and Risk, thereby facilitating analysis and interpretation of gaps based on an organization’s Threats and Vulnerabilities. The Worth and Value metrics facilitate critical examination of functional and performance requirements relative to the investment (Langford, et al., 2007). The Risk metric is used “to interpret the relevancy of data” (Langford, et al., 2007, p. 7). To understand these metrics, some definition is required.

Value for a given function (denoted by subscript  $f$ ) is defined as the ratio of the function’s delivered performance to the investment required to achieve these factors, assessed at a discrete moment in time,  $t$ , as:

$$\text{Value of a Function} = \frac{(\text{Performance})}{(\text{Investment})} = V_f(t) = \frac{\sum P_f(t)}{I_f(t)} \quad (1)$$

Value examines what was delivered versus how much it cost and can be viewed from the producer’s point of view (what was delivered in relation to what was paid for or the cost to produce it) or the customer’s point of view (what was received in relation to how much it cost or the time to acquire it). Value can be judged quantitatively through an objective measure of the magnitude of the cost, or qualitatively through a subjective perception of the benefits received (Langford, et al., 2007).

Value and Worth are not the same. Worth is an extension of the value concept that accounts for the uncertainty of loss involved in attaining that value, in terms of quality. Worth is determined from the product of value and quality, where quality serves as a “value correction factor” based on the loss of delivered value resulting from poor or inconsistent performance (quality is expressed here as the tolerance of performance, noted by the subscript  $p$ ):

$$\text{Worth of a Function} = (\text{Value})(\text{Quality}) = W_f(t) = V_f(t)Q_p(t) = \frac{\sum P_f(t)Q_p(t)}{I_f(t)} \quad (2)$$

That is, a decrease in quality implies either a lower level of performance or the effects of such, which constitutes a loss of capability, time, money, etc. Thus, one judges an alternative’s worth according to the risk of lost quality associated with pursuing that particular alternative in preference to another. In other words, a given alternative has higher worth if the risk of losing performance (i.e. reduced quality) is less than if a stakeholder chooses another alternative. The decision-maker determines that the value obtained is *worth* the effort expended in time or money (investment) (Langford, et al., 2007).

In the Enterprise Framework model, risk for a system element is defined in terms of Threats, Vulnerabilities, and the severity of the damage that occurs if the Risk becomes a reality. Threat ( $T_e$ ) is the likelihood that harmful events will have the ability to cause damage or degradation to the normal function of the element (that is, the probability of kill, or its moral equivalent in the case of HCM). Vulnerability ( $U_e$ ) is expressed as the probability that the element will be harmed or degraded through action by the threat. This is the complement of susceptibility ( $a_e$ ), which is the probability that the element will survive exposure to the threat:  $U_e = 1 - a_e$ . The concept of damage to the element is represented by a reduction in worth ( $W$ ) due to the loss (or reduction in value) incurred ( $L_e$ ).



Thus, the corrected worth of the element is expressed as  $W_e = W(1 - L_e)$ . Given these definitions, the risk for an element in the system is represented by:

$$\begin{aligned} \text{Risk} = R_e &= (\text{Threat})(\text{Vulnerability})(\text{Worth adjusted for loss}) = \\ T_e \cdot U_e \cdot W_e &= T_e \cdot (1 - a_e) \cdot W(1 - L_e) \end{aligned} \quad (3)$$

The manifestation of this risk is measured usually as the potential loss or degradation of the element in terms of money, but could be expressed also in terms of time or physical capital (Langford, et al., 2007). Note that it is a simple extension to characterize losses associated with human capital based on threats such as employees leaving the firm; the inability of the firm to hire employees with critical skills; the actions of competitors that devalue a firm's human capital; lack of a means to preserve corporate knowledge; or similar causes.

Applying the notions of Value, Worth, and Risk to a system, one measures the flow of these variables through use of Worth Transfer Functions (WTF), similar in concept to the WAF described in the previous chapter. The WTF expresses the exchange of value and worth between elements of a system at the point of interaction, and the risk involved in the transfer. In the previously defined expressions, the variables are indicated as functions of time to represent the instantaneous magnitudes of these metrics at the time of interaction. Via the WTF, the exchange is expressed in the Value/Risk Equation, in which the ratio of Value (in terms of Worth) to Risk for the interacting elements is equal:

$$\frac{W_{element_1}}{R_{element_1}} = \frac{W_{element_2}}{R_{element_2}} \quad (4)$$

Through means of WTFs, one can evaluate a given system state, transitions between system states, or the differences between the state of one system as compared to another. The elemental relationship of the WTFs allows them to be structured hierarchically according to the functional decomposition of the system

and examined at each level within the hierarchy. It should be noted that the expression in Equation 4 is a simplification to relate the dynamics of the interaction between two single elements based on the basic definition of risk discussed above. When extending this notion to interactions between multiple elements (three or more), the interaction increases in complexity and deals with the resultant aggregated risk for the group of interacting elements. Thus, Equation 4 is presented only as a means to illustrate notionally the dynamics of the WTF (Langford, et al., 2007).

### **3. Enterprise Framework Model Dynamics**

The Enterprise Framework is used to display the results of gap analysis graphically and integrates parameters related to business operations, strategy, and the product in terms of functionality, performance, and quality. It is an abstraction of the structures that define the decision trade-space, and is used to evaluate the interaction between the actions of competitors, the strategic choices made by the decision-maker, and opportunities taken—or not. The governing mechanism for the description of the relationship is the WTF in terms of the Value/Risk Equation, as described above, and the relationship between the threats and vulnerabilities facing the decision-maker. The equations presented in the previous section can be used to qualitatively describe the framework and govern its dynamics. Gaps are revealed via the relationship between threat, vulnerability, and worth/risk ratio (Langford, et al., 2007). This is depicted graphically in Figure 19 and Figure 20, in which the curves represent states of constant Worth/Risk.

Changes in threat, vulnerability, or worth govern movement within the framework. Threats to a system may appear, and by definition threaten the function or performance of the system. Vulnerabilities are defined by the state of the system. They appear based on the strategic choices made by the decision-maker and the perception of the threat. If one views threat and vulnerability in

terms of a quadratic loss profile (the lower the better / the higher the better), as in Figure 19 and Figure 20, the curve notionally represents a threshold of acceptable vulnerability. Above this threshold, the system is vulnerable, and below it, the system is not. Thus, if the threat and vulnerability are independent, regardless of the threat environment, and the state of vulnerability is acceptable, then the dynamics of movement within the Enterprise Framework space are viewed as a causal relationship between threat and vulnerability, represented by movement along the curve or between curves.

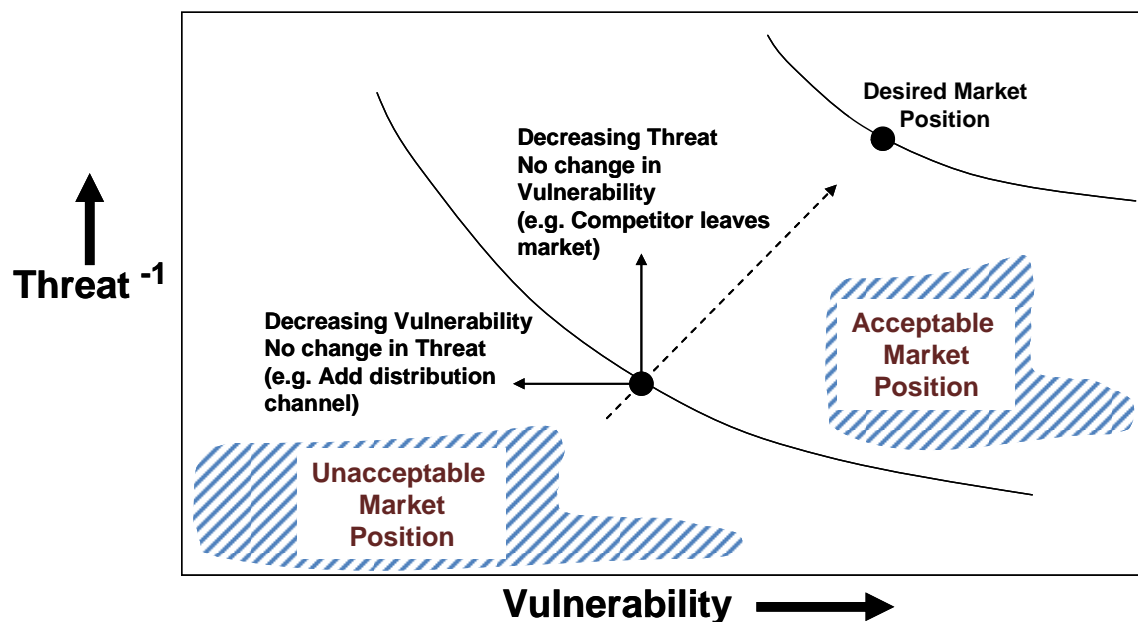


Figure 19. Gap Analysis Enterprise Framework Dynamics (After Langford, 2007a)

Thus, as shown in Figure 19, changing either the threat of vulnerability—and letting the other adjust accordingly—without changing worth moves the state point along the curve of constant worth/risk. Therefore, one can improve the state of the system by moving from an unacceptable position to a desired

position, or at minimum, to one of greater acceptability. However, if there is movement too far in either direction, an unacceptable point may be reached, resulting in a gap.

If there is no direct causal relationship between the threat and vulnerability, movement within the trade-space is represented by movement to another curve, signifying some change in the system, the threat, or the vulnerability. For example, as depicted in Figure 19, decreasing the threat, without a change in vulnerability necessitates a change in Worth/Risk (e.g., requires a shift to a new curve in the upward direction). Conversely, decreasing vulnerability without a change in threat shifts the curve to a new curve to the left (Langford, et al., 2007).

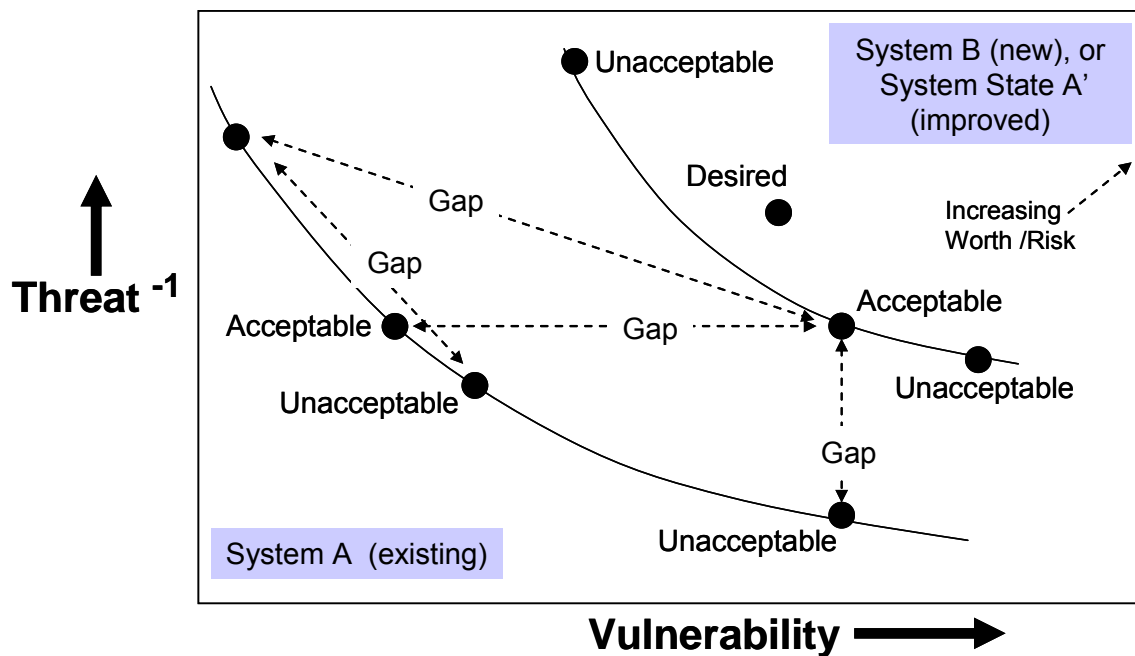


Figure 20. Gaps Visualized Using the Enterprise Framework (After Langford, 2007a; Langford, Franck, Huynh, & Lewis, 2007)

Therefore, based on this notional dynamic, as noted above in Figure 20, it is possible to reveal gaps based on unacceptable positions relative to acceptable

or desired positions without changing the worth (value) of the system by traveling along a single curve (System A in Figure 20). Additionally, it is possible to exhibit gaps between the two different states, which effectively is the difference between points on the existing system curve (System A in Figure 20) and the new or improved system curve (System A' or System B in Figure 20).

Upon perception of the gap, improving one's position involves changing the state of the system through one of the following means:

- The decision-maker may choose to increase the product value (worth), which causes a shift to a new curve (e.g. System A to System A').
- The decision-maker may choose to replace the product with a new product or an improved product with greater worth. Again, there is a shift to a new curve (System A to System B).
- The decision-maker may choose to decrease the system's vulnerability through implementation of new operational strategies or business practices, which moves the state point along the curve to one of greater desirability, while retaining the same product worth (System A).

By choosing the third option, an unacceptably high threat level could result when the desired state is reached, resulting in a gap. The causes of the high threat level could be due to the introduction of disruptive technologies, discontinuous innovations, or changes to the market environment due to new legislation or the entry of a new competitor. To address this issue, one must pursue steps that change the dynamic by shifting to another state (shifting to another curve, as discussed above) by devising a way to increase value through new or upgraded products or systems (Langford, 2007a, Langford et al., 2007).

The prior discussion shows the utility of the Enterprise Framework Model as a way to conceptualize gaps. In all cases, the model provides a means for determining the acceptability of a current state relative to other states that are possibly more desirable through an evaluation of threats, vulnerabilities, worth, and risks. The extent of the observed difference defines the gap and provides

insight regarding possible means to close the gap. Although mathematically defined, this framework provides a structured means to make qualitative judgments of gaps based on the information available to the decision-maker (Langford, et al., 2007).

#### **4. Application of a Gap Matrix**

Having qualitatively assessed the relationship between threats, vulnerabilities, worth, and risk in the Enterprise Framework, the understanding gained is used to guide the gap analysis. One method that is useful for capturing this analysis is use of a gap matrix. This method compares the elements of an existing architecture to those of a proposed architecture to point out issues that were overlooked and highlight critical stakeholder concerns that require attention during development of the new architecture (The Open Group, 2008).

To create the matrix, one aligns the functional elements of the existing architecture on the vertical axis, in this case features and practices of current HCM strategies. The elements of the proposed architecture are aligned along the horizontal axis. In this application, the stakeholder needs, as discussed in Chapter III, and the threat, vulnerability, worth, and risk assessments, discussed above, guide the choice of desired HCM strategy features and practices in the proposed architecture. As indicated in Figure 21, a column titled “Eliminated Services” and a row titled “New Services” are added to the matrix. The first step of the analysis is to compare in a pair-wise fashion the functional elements of the existing and proposed architectures. For existing functions that are also present in the proposed architecture, the intersection is marked “Included” or, in some cases, a partial match is noted. In instances in which the proposed architecture does not provide an existing function, a designation is made in the Eliminated Services column, indicating whether the elimination was deliberate, or unintended. Similarly, when a function in the proposed architecture does not appear in the existing architecture, entries in the New Services row designate

that provision for the feature must be included in the new system. Upon completion of this activity, entries in the Eliminated and New Services rows represent the gaps between the architectures (The Open Group, 2008). These results provide the necessary insight to guide and enhance the functional and effectiveness analyses discussed later in this work.

Proposed Architecture →					
	Element P1	Element P1	Element P1	Element P1	Eliminated Services ↓
Element E1					Intentionally eliminated feature
Element E2	Included				
Element E3		Partially Addressed			
Element En					Unintentionally excluded: A gap in proposed architecture
New Services →		Gap: To be enhanced or developed	Gap: To be developed or produced		

Figure 21. Example of a Gap Analysis Matrix (After the Open Group, 2000).

## **B. SHIPBUILDING INDUSTRY THREAT AND VULNERABILITY FACTORS**

Definition of human capital gaps within the United States shipbuilding industry begins with an examination of the factors influencing the current state of the industry, and the resultant affect on human capital. The results of this examination establish the threat and vulnerability characteristics required for performing a gap analysis guided by the Enterprise Framework model.

As a point of reference in the following discussion, it is helpful to first define the concepts of threat and vulnerability. According to Webster's Third New International Dictionary, a threat can be defined as "something that by its very nature or relation to another threatens the welfare of the latter" (Gove, p. 2382). Ayyub (2003) defines a threat as:

...a hazard or the capability and intention of an adversary to undertake actions that are detrimental to a system or an organization's interest. In this case, threat is a function of only the adversary or competitor and usually cannot be controlled by the owner or user of the system. However, the adversary's intention to exploit his capability may be encouraged by vulnerability of the system or discouraged by an owner's countermeasures. (p.38)

Additionally, the interaction between elements in a system, human or otherwise, and the hazard in question need not be intentional and is dependent on the chosen behavior of the element within the operating environment. In many cases, the hazard takes physical form. However, "soft" systems also have hazards, often associated with the interaction between people in organizations and the management structures and processes or between organizations and their business or market environment (Ayyub, 2003).

Regarding vulnerability, the Webster's Third New International Dictionary defines "vulnerable" as "capable of being wounded: defenseless against injury," and "open to attack or damage" (Gove, p. 2566-2567). Continuing in Ayyub's description, vulnerability is defined as "...a result of any weakness in the system or countermeasure that can be exploited by an adversary or competitor to cause



damage to the system “(p. 39). In sum, threat represents some danger resulting from the actions of an entity that has detrimental effects on the system. Vulnerability refers to the weakness within the system that allows the threat to damage or degrade its performance or operation.

For the purposes of this analysis, threats to the shipbuilding industry are defined in terms of the business environment that affects the ability of shipyards to efficiently design and build ships that satisfy customer needs and the ramifications to current HCM practices that result. These threats do not necessarily *intend* harm, but their actions can have damaging effects to human capital within the industry. Vulnerabilities are defined in terms of the weaknesses in the HCM strategies and practices pursued by shipyards as compared to perceptions and expectations from other stakeholders.

## **1. Shipbuilding Industry Threat Factors**

Two threat factors affecting the current state of the shipbuilding industry are military transformation and the Navy’s plans for acquisition of new ship designs. Both issues have implications regarding the future of the shipbuilding industrial base and the ability of the nation’s “Big Six” shipyards—General Dynamics’ Bath Iron Works, Electric Boat, and National Steel and Shipbuilding Corporation (NASSCO); and Northrop Grumman Corporation’s Shipbuilding Sector, composed of the Avondale, Ingalls, and Newport News shipyards (Dombrowski, Gholz, & Ross, 2002)—to remain viable as business entities.

### ***a. Effect of Military Transformation on Shipbuilding***

The phrase “Military Transformation” has been a buzzword within DoD since the turn of the 21<sup>st</sup> century, especially since the 9/11 terrorist attacks and the start of the GWOT. This transformation depends on changes to both the structure and management of military organizations and the means by which new weapons and communications systems are developed and implemented. The

cornerstone of this transformation is the idea of network-centric warfare (NCW), the goal of which is to shift military technology away from traditional “platform-centric” thinking to “network-centric” thinking. That is, instead of centering strategy on confrontations between platforms (i.e. ships, aircraft, vehicles, etc.), emphasis shifts to the means by which the distribution and routing of information throughout the battle space can enhance military effectiveness. NCW promises to increase the speed at which information flows throughout the battle space by facilitating greater situational awareness and speed of command; and allows the development of a common view of operations through enhanced information sharing (self-synchronization). The result is faster decision-making and less risk of miscommunication, leading to greater operational effectiveness (Dombrowski, et al., 2002).

The needs of NCW require changes to the design and construction of weapons systems, requiring them to be smaller, lighter, faster, and less complex than previous generations (Dombrowski, et al., 2002). This transformation depends on industry to develop and implement the necessary processes and technologies. Firms that primarily produce weapons platforms will have the most difficulty making the transition to a NCW environment because they build the nodes, not the network. NCW represents a disruptive change to the traditional approaches to innovation and system design used by such firms, especially shipbuilders (Dombrowski, et al., 2002).

Christenson (as cited by Dombrowski, et al., 2002) characterizes two forms of innovation: sustaining and disruptive. Sustaining innovation refers to product quality improvements based on known standards. A firm develops new and improved methods for meeting customer needs using prior or existing technologies. Re-use and modification of prior generations of technology tends to keep firms and suppliers in the business and draws on the strengths of those businesses that are adept at this form of innovation. Disruptive innovations, in contrast, are characterized by new technologies that exhibit disappointing initial

performance based on comparisons with traditional standards. However, over time, these technologies rapidly improve in performance and surpass the old technologies, even when measured by old standards. Due to the initial difficulty in predicting this progress, established firms tend to avoid the risk of developing and implementing them, leaving firms outside of the traditional sectors as main sources for development of the technology (Dombrowski, et al., 2002)

According to Dombrowski, et al. (2002), the “Big Six” shipyards can be characterized as sustainer innovators. Each has demonstrated an ability to evolve existing ship design concepts into better versions of their prior selves. However, they note “NCW advocates include disruptive innovations in the requirements that they set for the next generation of ships. Shipbuilding may well be the part of the defense industrial base that is most changed by military transformation” (p. 528). Shipbuilders have been pressured to build smaller quantities of larger ships that perform multiple missions and require more complex weapons and support systems integration. NCW forces capabilities that will require shipbuilders to rethink their traditional ship design and construction methods, with an emphasis on larger numbers of smaller, less-complex ships. In their view, this represents a significant and painful change for the “Big Six.” The transition involves both physical and human capital implications as they determine how to realign these assets to the changed environment. These firms are experienced at integrating a number of complex technologies onto a single platform, but will need to change the skill mix of their work force to accommodate the needs of the NCW environment. This mode of manufacturing has been compared to automobile or aircraft manufacturing as opposed to the current low-rate production with which shipyards are familiar. This new environment opens opportunities to enter the ship design market for smaller “second-tier” shipbuilders that have not traditionally participated in navy contracts or to firms that have traditionally focused on the mission systems integration aspect of shipbuilding rather than design and construction (Dombrowski, et al., 2002).

Therefore, there is a threat to the shipbuilding industry resulting from competition for contracts to create and build these new designs, which by their innovative nature will present competition for human capital.

Additionally, transformation forces a change in the type of engineers required. There is still a need for engineers with the basic skills of traditional disciplines. However, the amount of innovation that will be required in the new environment points to having engineers with a different mindset—that of a systems thinker, with a greater focus on program management and a ship design ability that encompasses a wider knowledge base involving multiple engineering disciplines—in addition to the traditional technical skills (Keane, 2007).

***b. Effect of Acquisition Schedules on Shipbuilding***

In recent years, the leaders of the “Big Six” shipyards, industry advocates, and leaders within the government, have expressed concern with the implications the U.S. Navy’s shipbuilding plan has for the industry, specifically the number of new designs being developed and the rate at which both new and existing designs are being constructed. These issues have significant effects on the ability of shipyards to maintain capability to produce ships that meet the needs of the Navy, while delivering them on schedule and within budget.

As referenced earlier, Michael W. Toner, Executive Vice President of General Dynamics’ Marine Systems Division testified to the U.S. Senate regarding effect of the U.S. Navy’s procurement plans on the future of the shipbuilding industry. He notes that as of the conclusion of class design for the U.S.S. Virginia class submarines, for the first time since the 1960’s, there are no new submarine designs in development. In addition, current designs are being procured in fewer numbers and at longer build intervals between hulls (one per year, split between Electric Boat and Northrop Grumman’s Newport News Shipyard). This decline in procurement has a profound effect on the

manufacturing base, particularly in terms of the loss of corporate knowledge. As engineering talent leaves the industry in pursuit of other work, a loss of the unique skills required to design and build submarines, such as acoustics and stealth, hydrodynamics, shock, nuclear propulsion, and submarine component integration, results. This knowledge takes considerable time to develop and depends upon a constant volume of work to maintain the currency of technical knowledge. Once the knowledge leaves the industry, engineers from other shipbuilding disciplines must fill the need for technical expertise. Typically, the lack of requisite knowledge results in programs that run over budget and fall behind schedule as the lost technical knowledge is re-learned (Toner, 2005).

As is the case with submarine procurements, the number of new surface combatant designs has declined, with fewer ships of existing design being built. The effect on the engineering work force required is similar. According to Toner, as of 2005, it took three years and approximately \$60-90 thousand to develop an engineer proficient in the unique skills required for ship design and integration. This time delay, coupled with the low-rate procurement pattern has an effect on shipyard performance in two ways: (1) the lack of a consistent work volume forces shipyards to downsize the engineering staff and encourages engineers to leave the industry voluntarily; and (2) once a new design or construction contract is let, it takes a significant portion of the design cycle to train engineers in the unique skills required for shipbuilding. Again, the implications are increased costs and delays in ship construction. In Toner's words:

Unanticipated or uncontrollable changes in volume have a significant impact on the cost of an hour's worth of labor. While facilities can be readily re-tooled or taken off-line, this country's highly-skilled shipbuilders (engineers, designers and craftsmen) are a national treasure; they cannot simply be placed in "reserve" status (2005, p. 32).

These sentiments were echoed in 2005 by then President of Northrop Grumman's Gulf Coast Shipyards, Phil Dur, who stated that reductions in build quantities and increased order intervals for ships have a negative effect on the future of the industrial base, and expressed the following concerns:

The highly skilled workforce in our [Northrop Grumman's] shipyards will have gone off to other jobs...and new workers will not have been trained.

The extraordinary intellectual capital – the engineers, designers, scientists – will have migrated to other industries that are seen to have a future, where, believe me, their skills are in high demand.

The next-generation technologies being developed for ships like the DD(X) will never have been developed – and the diaspora [sic] of the best and brightest naval engineers will severely limit future choices.

In short, you don't just turn a switch for shipbuilders to generate new capacity. (p. 6)

Thus, an inconsistent work volume makes it more difficult to retain human capital and capture the corporate knowledge required to remain competitive.

From the above, the "Big Six" shipyards have stated that a continuous work volume created by the adoption of a stable procurement schedule would contribute greatly to reducing the loss of critical skills required to build efficiently the Navy of the future. The need to maintain the shipbuilding industrial base was included as one of the goals of the Navy's Fiscal Year 2007 shipbuilding plan, in which the size of the Navy was projected to increase from 281 ships (as of 2006) to an average of 309 by 2036, including the development of new ship classes. However, the GAO has expressed concerns whether the Navy will have the resources, both in terms of funds and the necessary engineering knowledge, for designing and building the required ships. Furthermore, due to the complexity of the systems aboard the ships, the GAO questions whether the Navy will be able to control costs sufficiently (GAO, 2006).

These changes are not in the control of the shipyards and introduce greater uncertainty into the business environment, placing the valuable human capital within the industry at risk.

## **2. Shipbuilding Industry Vulnerability Factors**

Two vulnerability factors within the shipbuilding industry are its difficulty attracting new engineering talent, and the loss of critical skills due to retirement and competition from other industries. These vulnerabilities are related to institutional processes and biases that prevent the human capital within the industry from being developed and managed in a manner that maximizes its productive efficiency in support of the business environment described in the previous section.

### ***a. Difficulty Attracting New Talent***

Several issues affect the attraction and development of new engineering talent to the shipbuilding industry. A study conducted by the Massachusetts Institute of Technology (MIT) at the request of the Office of Naval Research (ONR), describes the problem in terms of relationships between three primary stakeholders, Academia, Industry, and Students, specifically concerning the conflicts between each party's priorities. This vulnerability is characterized by exploring the contrasting goals of Industry vs. Academia; Students vs. Industry and the Naval/Marine Engineering profession; and Academia vs. Industry (Chrysostomidis, Bernitsas, & Burke, 2000).

In the case of Industry vs. Academia, the contrast in goals is in terms of the education of students and the nature of the skills they possess as they enter the shipbuilding industry. Shipyards desire engineers that are ready to perform specific job skills and requirements tailored to the needs of industry immediately upon entering the workforce, especially expertise in software tools. However, the university focus is on graduating students with the skills that will

prepare them for a long career and are therefore more broadly oriented. Compounding the issue is the nature of work at U.S. shipyards. This work is disproportionately focused on defense-related (i.e., U.S. Navy) programs instead of commercial projects. As noted above, defense shipbuilding is typically low-rate production, with the generation of relatively few designs that are built repeatedly over a 15-20 year span. The low number of designs amplifies the consequences of failure, fostering a very risk-averse environment. Such aversion is detrimental and creates barriers for innovation. The result is that engineering students are less attracted to the naval and marine engineering field because they desire work in fields that they consider exiting and that use new technology. Additionally, university professors, who focus heavily on research opportunities and knowledge sharing, do not perceive the shipbuilding industry as fertile ground for their research interests. Finally, industry's competitive focus is incompatible with Academia's idea of openly sharing such research-derived knowledge (Chrysosostomidis, et al., 2000).

In the case of Student vs. Industry and the Naval and Marine Engineering profession, the issues are characterized by the desire of students to seek an education that provides the greatest (widest) applicability, and thus a greater career opportunity. Consequently, they enter engineering disciplines that are most likely to fulfill this need, such as mechanical, electrical, or civil engineering, or computer science. However, students generally are not aware of the career opportunities in the naval and marine engineering or the type of work challenges within the industry and perceive it as less exotic in terms of the principal attractors, especially stimulating design work, application of new technologies, and use of the latest computer tools. Salary disparities within the naval and marine engineering field, which are typically lower than for the other disciplines, especially computer science, reinforce this perception. Together, these factors result in a low enrollment of prospective engineers in naval and



marine engineering curriculums and fewer programs that teach the industry-specific skills required for shipbuilding (Chrysostomidis, et al., 2000).

Finally, as noted above, in contrast to Industry, Academia (university professors) focuses heavily on research and development opportunities. There exists a strong competition with other engineering disciplines for research funding and available faculty. Often, naval and marine technologies are already mature or mature relatively quickly. Upon reaching maturity, such technologies are less inviting for research. The rate of technology maturation often exceeds the ability to hire new faculty that is interested in research opportunities. That is, the technology matures so quickly that the research opportunities diminish before interested research faculty can be hired. This encourages new faculty to specialize in the other engineering disciplines. The lack of available specialty professors also results in low student enrollment and creation of fewer programs that focus specifically on the naval and marine engineering discipline (Chrysostomidis, et al., 2000). The human capital implication arising from these factors is a shipbuilding industry vulnerable to shortages of new qualified engineering talent due to a lack of awareness of the opportunities within the industry (i.e., a “public relations problem”), exacerbated by an infertile research relationship with academia, and a perception by students that very little new engineering is performed. Overcoming this condition requires shipyards to change their approach for attracting and developing new talent.

#### ***b. Development and Retention of Critical Skills***

Both industry and government are subject to the general demographic trend related to the retirement of the baby boomer generation. Significant portions of the work force are reaching retirement age. By some estimates, up to half of the federal work force was between 49 and 69 years old as of 2003, and is projected to increase to 70 percent by 2010 (Schwarz, 2004).

Industry faces a similar problem. According to Ian Ziskin (as quoted by Brandon, 2008), chief of human resources and administrative officer for Northrop Grumman Corporation,

If you look at the demographics of the workforce for Northrop Grumman, which are pretty consistent with the demographics of the aerospace and defense industry in general, we have about 122,000 employees, approximately 50 percent of whom will be able to retire over the next five to 10 years (p. 1).

The effect on the workforce is the risk of losing the institutional knowledge and experience required to sustain effective operations. According to the GAO, this has become a “fundamental weakness” in federal agencies requiring a strategic human capital response (GAO, 2000). As noted in the testimony from industry discussed above, this is a critical issue for shipyards, as well, since the required skills and knowledge cannot be regenerated quickly, once lost.

A specific example of how the loss of critical skills affects the shipbuilding industry is the expertise required to maintain the nation’s submarine-launched ballistic missile (SLBM) force. According to the Defense Science Board, the science and engineering personnel equipped with the unique expertise required to design, build, and maintain SLBM strategic strike technologies cannot be obtained from the general workforce, since the required knowledge is often classified and stays within the DoD domain. Downsizing due to the end of the Cold War, a decrease in procurement of new systems, and the aging of the workforce has placed the critical skills at risk of being lost. The decreased inflow of new talent, as described in the previous section, threatens to hamper the ability of industry and DoD to maintain the required expertise. In order to design the next generation of SLBM systems, some means to capture the knowledge and pass it to future generations of scientists and engineers is required (OUSD AT&L, 2006).

Other segments of the shipbuilding industry have echoed this need. In Keane's (2007) presentation to the National Naval Engineering Education Conference, he stressed that successful organizations depend on a strong core of engineering talent. However, the wave of retirements from the baby boomer generation, combined with limited hiring practices during the 1980's has resulted in an experience gap. Younger and less experienced workers are left to take up the workload of the retiring engineers. In addition, there is no means established to fill the gap with new workers or to capture and transfer the benefit of their experience. Keane cites Peter Noble, Chief Naval Architect at Conoco Phillips, who has stated that the industry must find a way to "provide Accelerated Knowledge Transfer to jump start young graduates to cover the experience gap from the 50+ year-olds to the 25-30 year-olds at a faster pace than would occur through normal work practices" (Keane, slide 6).

In both of these examples, the result has been a call to address the development and retention of the shipbuilding skill base. At the urging of the Office of Naval Research (ONR), the National Naval Responsibility for Naval Engineering (NNR-NE) program was created. Its purpose is to create a joint Industry-Academia-Government initiative to capture the critical naval and marine engineering skills and transfer them to the next generation of engineers while still in the academic environment (Chrysostomidis, 2000; Keane, 2007). In the case of retention of SLBM-related strategic skills, the Defense Science Board has recommended the Secretary of Defense mandate the Services to "devote resources to the transfer of knowledge and skills critical to the sustainment of future strategic strike mission[s] to younger personnel in industry" (OUSD AT&L, 2006, p. C-2). Additionally, it was recommended that DoD extend the initiative to its contractors and make the establishment and demonstration of mentoring, training, and related programs necessary for the transfer of critical skills and knowledge a factor in contract awards (OUSD AT&L, 2006). In sum, there exists a clear consensus that the shipbuilding industry lacks a mechanism for

sustaining the skill level of its human capital. The engineering skill base, which is sensitive to such demographic changes, could quickly evaporate if industry and the DoD do not take proactive measures to address the problem.

### **C. SHIPBUILDING INDUSTRY HUMAN CAPITAL GAP ANALYSIS**

The previous discussion of threats and vulnerabilities and the results of the stakeholder analysis performed in Chapter III have provided the insight necessary to define the gaps in shipbuilding industry HCM strategies. These insights allow the assessment of top-level features for existing HCM strategies and initial assignment of proposed top-level functions for a new HCM architecture.

As described earlier in this chapter, the existing and proposed functions are entered into a gap matrix and compared in a pair-wise fashion to determine the extent to which the proposed elements include or exclude elements from the existing architecture. The gap is defined based on the extent of the difference between the two, and identifies areas for enhancement or development that must be satisfied in the new architecture. In addition, the evaluation will determine if any features were omitted (purposely or inadvertently) from the new architecture.

The following elements were derived for the existing shipbuilding industry HCM architecture, based on the prior analysis and have been entered along the left side of the gap matrix, as shown in Figure 22:

- Knowledge Management
- Industry-Government Relationships
- Industry-Academia Relationships
- Development and Implementation of Training
- Career Path Development
- Competitive Compensation
- Proactive Development of Subject-Matter Experts (SMEs)
- Shipbuilding Opportunities Awareness

Proposed Architecture										Existing Architecture	
	Knowledge Management	Industry/ Govt./ Academia Partnerships	Develop & Implement Training	Career Path Development	Competitive Compensation	Identify Potential Talent	Interactive Recruitment of Potential Talent	Implement HCM Strategy	Proactive Development of SME's	Shipbuilding Opportunities Awareness Campaign	Eliminated Services
Knowledge Management	Partially Addressed										
Industry/ Govt. Relationships		Partially Addressed									
Industry/ Academia Relationships		Partially Addressed									
Develop & Implement Training			Partially Addressed								
Career Path Development				Partially Addressed							
Competitive Compensation					Partially Addressed						
Proactive Development of SME's									Partially Addressed		
Shipbuilding Opportunities Awareness Campaign										Partially Addressed	
New Services	Gap: To Be Enhanced	Gap: To Be Enhanced	Gap: To Be Enhanced	Gap: To Be Enhanced or Developed	Gap: To Be Enhanced	Gap: To Be Developed	Gap: To Be Developed	Gap: To Be Developed	Gap: To Be Enhanced	Gap: To Be Enhanced	

Figure 22. Shipbuilding HCM Gap Matrix

The notional elements of the proposed new HCM architecture are indicated along the top of the gap matrix as shown in Figure 22. They are as follows:

- Knowledge Management
- Industry-Government-Academia Partnerships
- Development and Implementation of Training
- Career Path Development
- Competitive Compensation
- Identification of potential engineering and science talent at the secondary and post-secondary education levels
- Interactive recruitment of potential talent at the secondary and post-secondary education levels
- Implementation of a HCM strategy
- Proactive Development of Subject-Matter Experts (SMEs)
- Shipbuilding Opportunities Awareness

Description of the elements of both architectures is presented in Chapter V.

The gaps between the two architectures are indicated at the bottom of Figure 22. In general, gaps exist with respect to every feature in the existing architecture, of which three are completely new features (identification and interactive recruiting of talent and development of a HCM strategy); while the remaining elements require modification in order to provide the necessary functionality. Based on the discussion and analysis in the prior chapters, this result is not surprising.

An example based on the personal experience of the authors, the element “Career Path Development” is part of the current architecture but has not been an institutional focus within shipbuilding companies. Typically, employees are required to define their own program for development and advancement. In the proposed architecture, HR departments, in conjunction with engineering

management, have developed defined processes and guidance for employees at every level, from entry-level to upper management. This guidance defines the possible paths of advancement and the necessary requirements for promotion to the next level. The difference is that the proposed architecture contains a systemic, repeatable process with clear expectations for career growth.

#### **D. CHAPTER SUMMARY**

This chapter examined the gaps facing the shipbuilding industry using the Enterprise Framework model developed by Langford, et al. as a guide. The Enterprise Framework allows conceptualization of how threat, vulnerability, worth, and risk combine to illuminate an existing state and a desired state. The difference between these states defines the gap.

This analysis discussed how threat factors related to the change in the nature of the systems necessitated by military transformation would stress the shipbuilding industry's ability to produce products to meet the future needs of the Navy. Transformation will force both a change in the design and construction methods and in the nature of the engineering talent required to build future ship systems. In addition, the procurement pattern and work volume faced by shipyards have serious implications for the retention of knowledge and maintenance of skill levels within the workforce. Low-rate production coupled with lengthy intervals between build-starts and fewer new design developments present challenges to shipyards to train and retain engineering talent. The repeated need to traverse learning curves has profound impacts on the ability of shipyards to build ships economically.

Concurrently, shipyards are vulnerable to an insufficient flow of new talent due primarily from a lack of awareness of the challenges and rewards offered by a career in naval and marine engineering and competition for talent from other engineering disciplines. Due to the differing goals within industry, government, and academia, an insufficient number of graduates and faculty are attracted to

the discipline and opt for work or research opportunities in other engineering disciplines. In addition, the industry faces a crisis caused by a mass exodus of baby boomer generation engineers that are eligible for retirement within the next ten years. Retirees take with them the vast base of knowledge and critical skills learned from a long shipbuilding career. This crisis leaves shipbuilding vulnerable to a “brain-drain” if action is not taken to capture these critical skills and transfer them to the next generation of engineers that will carry on the work.

The gap analysis indicates that there is much room for improvement in the HCM systems currently in use in the shipbuilding industry. These range from improvements in knowledge capture and transfer; to improved relationships between government, industry, and academia; development of new ways to attract and evaluate talent (starting at the middle- and high school age levels, and continuing at the university level); development of defined career paths, improved training; and building awareness of the career opportunities within the industry. These insights will be used to facilitate the Functional Analysis and Overall Measure of Effectiveness Model presented in the next chapter.



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## **V. FUNCTIONAL ANALYSIS AND OVERALL MEASURE OF EFFECTIVENESS MODEL**

### **A. HCM CONCEPTUAL DESIGN**

This chapter discusses how the data from the previous chapters is integrated using the Systems Engineering conceptual design processes Functional Analysis and Effectiveness Modeling. This analysis establishes a foundation to illustrate how one could develop a specific HCM architecture for DoD Shipbuilding Technical Expertise using the components described in the prior chapters. The processes outlined in Blanchard & Fabrycky's, *Systems Engineering and Analysis*, 4th edition (2006), are used to guide the Systems Engineering methods used for the analysis. The latter portion of the chapter shows how the resulting architecture may be evaluated using a notional overall measure of effectiveness (OMOE) model to demonstrate how stakeholders could investigate alternative design solutions to fulfill the functions within the architecture.

#### **1. Conceptual Design**

As specified in Blanchard and Fabrycky (2006), the Systems Engineering activities associated with the conceptual design phase for a system are as follows:

- Requirements Analysis
- Functional Analysis
- Requirements Allocation
- Trade-Off Studies
- Synthesis
- Evaluation
- Type A Specification
- Design Reviews

The focus of this study is the conceptual design of a DoD Shipbuilding Technical HCM Architecture with specific emphasis on the initial steps of the concept design phase: Requirements Analysis, Functional Analysis, and Evaluation. The purpose is to illustrate the tools and methods a decision maker would apply to develop a HCM Architecture to meet the unique needs of shipbuilding and link the architecture to the global needs of the Shipbuilding Technical Industry.

## **2. Requirements Analysis**

The focus of the Requirements Analysis effort is problem definition, identification of stakeholder needs, how these needs are translated into stakeholder requirements, and how gaps in current DoD HCM architectures (in conjunction with the stakeholder requirements) are used to inform the Functional Analysis. Chapter I introduced the problem of acquiring and retaining technical expertise related to the DoD Shipbuilding Industry. Chapter II provided the background understanding of the purpose of a HCM architecture, and how it should function. In Chapter III, stakeholders associated with the problem were identified and categorized in order to provide a landscape assessment of stakeholder needs. Once these needs were captured, stakeholder requirements were developed to clarify these needs. Gaps in current HCM architectures were examined in Chapter IV. The data from each of these analyses is used to guide the Functional Analysis and create a notional functional architecture for HCM. Table 17 and Table 18 show the linkage between the gaps discussed in Chapter IV and the top-tier functions of the proposed HCM architecture.

Gap #	Gap Description
Gap 1	Knowledge Management
Gap 2	Industry-Government-Academia Relationships
Gap 3	Develop and Implement Training
Gap 4	Career Path Development
Gap 5	Competitive Compensation
Gap 6	Identification of potential talent (secondary and post secondary educational level)
Gap 7	Interactive recruitment of potential talent (secondary and post secondary educational level)
Gap 8	Implement HCM Strategy
Gap 9	Proactive development of SMEs
Gap 10	Awareness campaign of Shipbuilding Opportunities

Table 17. Gaps In Current DoD HCM Architectures for the DoD Shipbuilding Technical Industry.

Function #	Function Description	Gaps									
		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
1	Facilitate Knowledge Management	X									
2	Manage Industry-Government-Academic Partnerships		X								
3	Administer Appropriate Training			X							
4	Develop Career Paths				X						
5	Institute Competitive Compensation					X					
6	Identify Potential Talent						X				
7	Utilize Interactive Recruitment							X			
8	Implement HCM Strategy								X		
9	Apply Proactive SME Development									X	
10	Conduct Shipbuilding Opportunity Awareness Campaign										X

Table 18. Gap-to-Function Traceability Matrix.

Table 19 and Table 20 show the linkage between the stakeholder requirements discussed in Chapter III and the top-tier functions of the Functional

Analysis. These tables illustrate how the top-tier functions in the Functional Analysis can be traced to the requirements derived in Chapter III and the gaps discussed in Chapter IV.

Requirement #	Requirement Description
<b>Requirement 1</b>	Enhance the ability of shipbuilders to retain and maintain technical workforce expertise in a low-rate production environment
<b>Requirement 2</b>	Encourage university and secondary educational entities to promote awareness of opportunities in the shipbuilding technical industry
<b>Requirement 3</b>	Promote the development of curricula at the university level associated with naval engineering and related fields
<b>Requirement 4</b>	Promote the increase of industry resources needed to recruit, train and maintain a complete technical workforce
<b>Requirement 5</b>	Facilitate the transfer of industry specific technical knowledge between industry entities and the industry workforce
<b>Requirement 6</b>	Facilitate a means for technical knowledge capture
<b>Requirement 7</b>	Enhance the ability of industry, government and academic entities to promote innovation and advancements in the technical shipbuilding community
<b>Requirement 8</b>	Encourage students at the university and secondary educational level to consider naval engineering and related fields as viable careers options
<b>Requirement 9</b>	Enhance technical job growth in the industry in order to compete with other fields such as Computer Science and Medicine
<b>Requirement 10</b>	Encourage the increase of technical worth of the current industry workforce

Table 19. Stakeholder Requirements of DoD HCM Architecture for DoD Shipbuilding Technical Industry.

Function #	Function Description	Requirements									
		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
1	Facilitate Knowledge Management	X				X	X				X
2	Manage Industry-Government-Academic Partnerships	X	X	X				X		X	X
3	Administer Appropriate Training				X	X	X				X
4	Develop Career Paths								X	X	
5	Institute Competitive Compensation								X	X	
6	Identify Potential Talent								X		
7	Utilize Interactive Recruitment		X		X						
8	Implement HCM Strategy		X		X			X			
9	Apply Proactive SME Development					X					X
10	Conduct Shipbuilding Opportunity Awareness Campaign	X	X							X	

Table 20. Requirement/Function Traceability Matrix.

### 3. Functional Analysis

According to Blanchard & Fabrycky (2006), “A function refers to a specific or discrete action (or series of actions) that is necessary to achieve a given objective” (p. 78). Functional Analysis is the process of associating stakeholder requirements to these functions, which are then used to develop other elements of the system architecture. The Functional Analysis is critical to system architecting in that it provides the foundation for the translation of system requirements into the physical elements of the system. The Functional Analysis was conducted by using a Functional Decomposition methodology. Functional Decomposition is the process of identifying and grouping system functions in a hierarchical manner to give the system developer a concept of how the architecture should be developed (Blanchard & Fabrycky, 2006). The decomposition consists of a series of functions and related sub-functions (see Figure 23).

Using this methodology, a functional decomposition for the HCM technical architecture top-tier functions was devised based on the results of the analyses in the previous chapters, as shown in Figure 24. Each function is discussed in turn in the following sections.

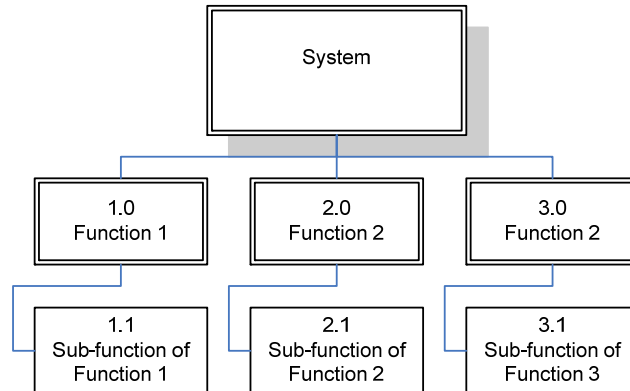


Figure 23. HCM System Functional Decomposition.

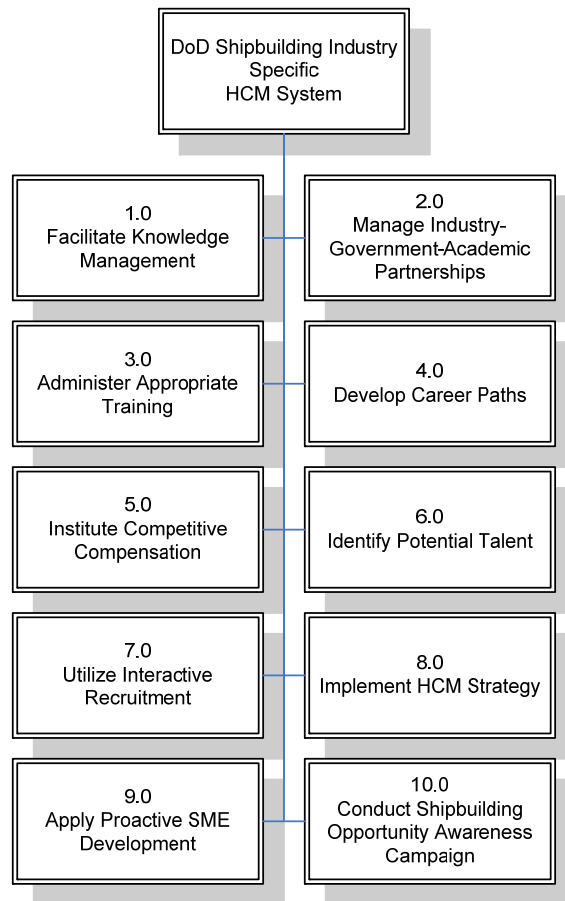


Figure 24. Top-tier Functional Decomposition of HCM Architecture for DoD Shipbuilding Technical Industry.

**a. Function 1.0: Facilitate Knowledge Management**

Figure 25 depicts the decomposition of top-tier Function 1.0, “Facilitate Knowledge Management.” The concept of Knowledge Management is characterized functionally by examining the acts of Knowledge Capture and Knowledge Transfer. Knowledge Capture is the act of isolating and retaining the technical knowledge critical to the success of a DoD Shipbuilding program. Knowledge Transfer is the act of moving this captured technical knowledge from the retention source to sources that will need to use the knowledge (both in the present and future) to facilitate successful DoD Shipbuilding programs.



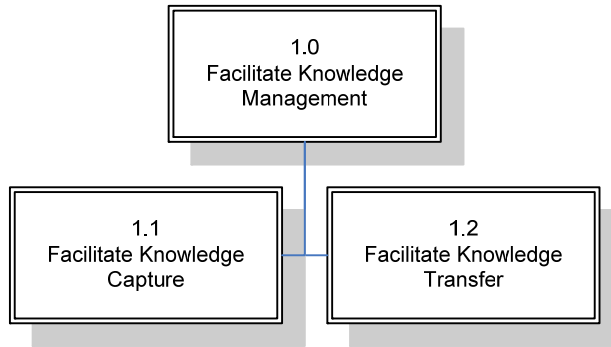


Figure 25. Decomposition of Top-Tier Function “Facilitate Knowledge Management.”

***b. Function 2.0: Manage Industry-Government-Academic Partnerships***

Figure 26 depicts the decomposition of top-tier Function 2.0, “Manage Industry-Government-Academic Partnerships.” The idea of managing interagency partnerships can be illustrated by managing student-to-engineer relationships, providing mentoring, and supporting industry sponsorships. Managing student-to-engineer relationships is the act of establishing, nurturing and growing professional relationships between students at the secondary and post-secondary educational levels with engineers at all levels of experience within the DoD shipbuilding industry. Management of Industry-Government-Academic partnerships then facilitates the function of providing mentoring.

Mentoring of students and young engineers is critical to the growth of the technical talent pool for the DoD shipbuilding industry, which in turn encourages sponsorship opportunities. Sponsorship (educational, financial, material, etc.) of professors and teachers at these educational levels increases the likelihood that students will be exposed to the DoD shipbuilding industry as well as developing an academic base from which expertise in the naval and marine engineering discipline is grown and enhanced.

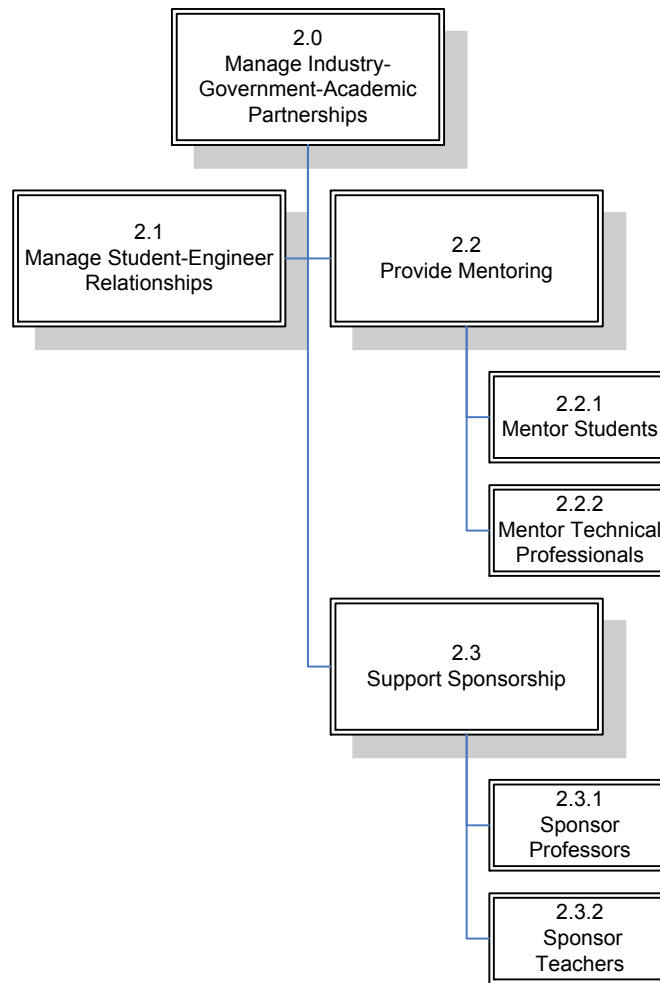


Figure 26. Decomposition of Top-Tier Function “Manage Industry-Government-Academic Partnerships.”

**c. Function 3.0: Administer Appropriate Training**

Figure 27 depicts the decomposition of top-tier Function 3.0, “Administer Appropriate Training.” Administering Appropriate Training consists of providing training resources, providing training funding, and providing the necessary tools to facilitate training. Providing Training Resources is the act of identifying and implementing the training necessary for the development of a competent technical workforce for the industry. Provision of these resources

requires a dedicated funding source that not only supports the present training needs, but also changes as the training needs change over time. Finally, provision of appropriate training tools is required to support administration of the training and is therefore a dedicated function itself.

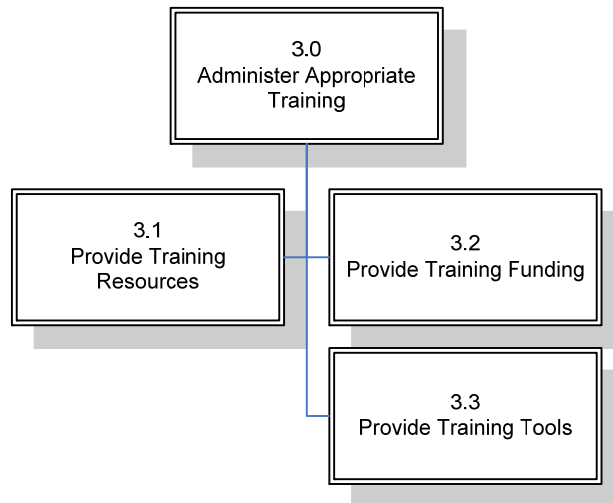


Figure 27. Decomposition of Top-Tier Function “Administer Appropriate Training.”

**d. Function 4.0: Develop Career Paths**

Figure 28 depicts the decomposition of top-tier Function 4.0, “Develop Career Paths.” Career path development for the work force is the responsibility of every progressive employer. This function is defined in terms of succession planning, encouraging career growth, and facilitating career longevity. Promoting Succession Planning is the act of examining present workforce technical demographics and developing plans to maintain these demographics as individuals move in and out of the talent pool. This action is accomplished through the act of encouraging the present workforce to consider career growth opportunities in their chosen fields.

Some industries have stifled this activity due to the limited number of positions available as individuals move up the technical ranks. However, to

ensure that individuals in the workforce stay engaged, the act of encouraging career growth must be realized. Facilitating Career Longevity of the technical workforce leverages the act of encouraging career growth. If individuals in the technical workforce did not perceive the opportunity for growth in their chosen field, they might be inclined to change to non-technical fields to achieve career goals. By facilitating career longevity plans, employers can ensure that the current technical talent within their organizations will increase and reach a higher level of refinement.

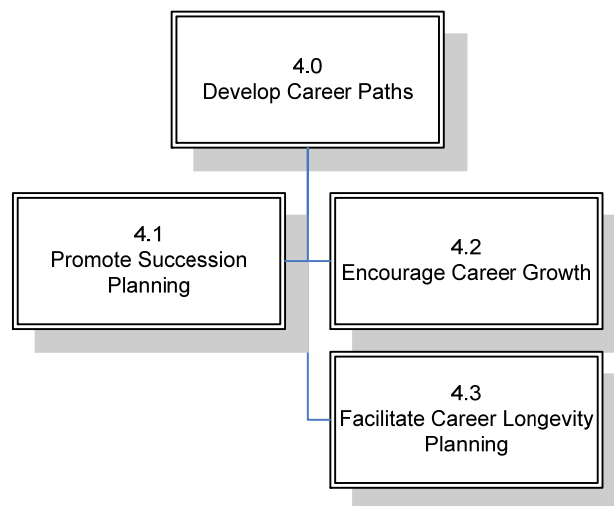


Figure 28. Decomposition of Top-Tier Function “Develop Career Paths.”

**e. Function 5.0: Institute Competitive Compensation**

Figure 29 depicts the decomposition of top-tier Function 5.0, “Institute Competitive Compensation.” Instituting Competitive Compensation is defined as the iterative act of publishing salary and cost of living data and monitoring national technical and engineering salary adjustments. Publishing salary and cost of living data can be accomplished by separately distributing the data both within the company and to the public. The purpose of publishing this data is two-fold. First, the data can be used as a recruiting tool to show potential

technical employees how the industry compares to other industries that may have higher salary jobs, but reside in areas where the cost of living is dramatically higher. Second, the data can assure the current shipbuilding industry workforce that management understands their salary needs. In addition, this demonstrates to the shipbuilding workforce that employers are monitoring national technical and engineering salaries to adjust them continuously based on labor market dynamics.

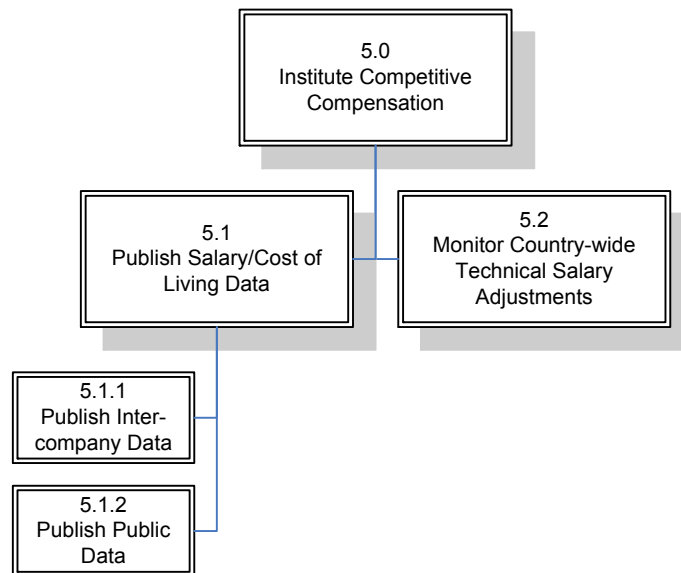


Figure 29. Decomposition of Top-Tier Function “Institute Competitive Compensation.”

***f. Function 6.0: Identify Potential Talent***

Figure 30 depicts the decomposition of top-tier Function 6.0, “Identify Potential Talent.” The engagement of students, development of a talent identification methodology, and implementation of the methodology characterize functionally the concept of identifying potential talent. The engagement of pre-secondary, secondary and post-secondary students is different than mentoring in that the purpose for the engagement activity is to identify potential technical and

engineering talent at an early level within the educational system. To accomplish this task, a proactive talent identification methodology is required. A novel approach for this methodology is to model it after the collegiate athletics or U.S. Armed Services models. In these models, recruiters actively seek to identify candidates through focus group discussions, attending school-sponsored events (such as academic bowls, technical design competitions, etc.) and supporting academic extracurricular activities such as engineering societies. Once this methodology is developed, a systemic implementation of the methodology is necessary to achieve the top-tier function.

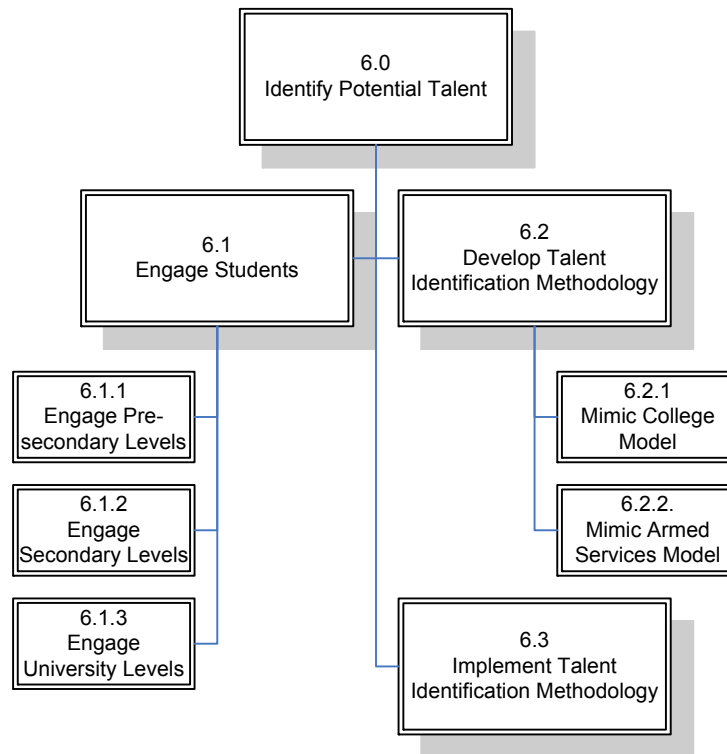


Figure 30. Decomposition of Top-Tier Function "Identify Potential Talent."

***g. Function 7.0: Utilize Interactive Recruitment***

Figure 31 depicts the decomposition of top-tier Function 7.0, “Utilize Interactive Recruitment.” Utilization of interactive recruitment is a concept closely related to the previous function “Identify Potential Talent.” The development of an interactive talent recruiting model changes the current recruiting paradigm of sitting at a recruiting table (for example at a job fair) and waiting for potential technical talent to interact with a recruiter. Instead, recruiting becomes proactive. Again using the collegiate athletics or US Armed Services models, once potential technical talent is identified, recruiters take the initiative to encourage this talent to pursue a career in the DoD Shipbuilding industry. After development of the methodology, the interactive model for recruiting talent should be implemented.

Related sub-functions are the development of a technical expertise replenishment strategy and the implementation of such strategy. In a manner similar to succession planning, this strategy examines the current state of the technical expertise of an organization, but instead focuses on the means of replenishing this expertise (not just the people) as it changes in response to shifts in technological innovation. Once the strategy is developed, it should be implemented to ensure the industry remains competitive with other industries, such as Computer Science and Medicine.

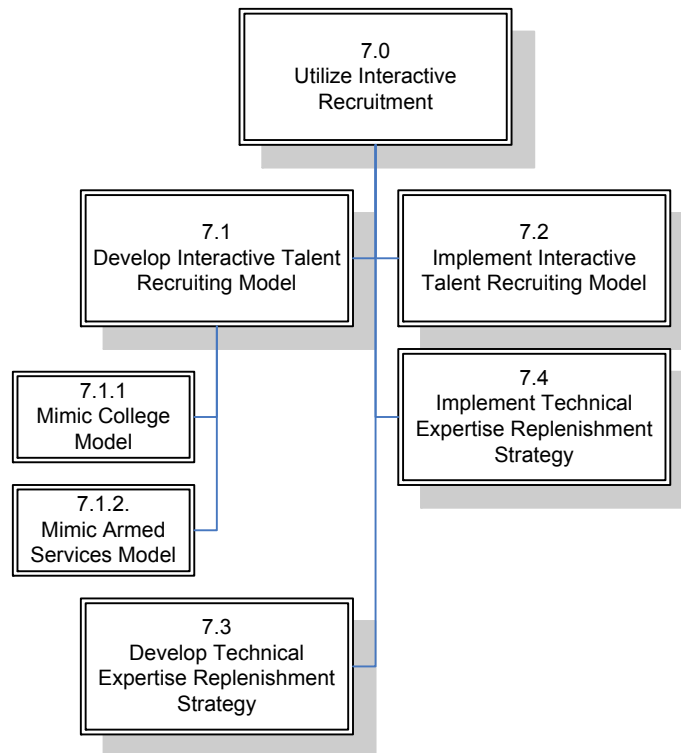


Figure 31. Decomposition of Top-Tier Function “Utilize Interactive Recruitment.”

#### ***h. Function 8.0: Implement HCM Strategy***

Figure 32 depicts the decomposition of top-tier Function 8.0, “Implement HCM Strategy.” The implementation of a HCM strategy is a critical function within the HCM architecture. The sub-functions associated with this top-tier function are as follows:

- **Integrate HCM Elements:** This is the act of ensuring the interfaces between architectural elements are identified and mapped. This effort follows the Systems Engineering approach and ensures that all HCM elements have the proper inputs and outputs identified.
- **Develop HCM Processes:** This is the act of using a standardized method to develop and document the processes needed to support the HCM technical architecture.



- **Implement HCM Processes:** This is the act of implementing the documented processes and noting any corrective actions needed to accomplish process maturity.
- **Mature HCM Processes:** This is the act of using the actions from the previous sub-function to improve the process continuously using a standardized method.

These functions are critical to successful deployment and maintenance of a HCM technical architecture for the DoD Shipbuilding industry.

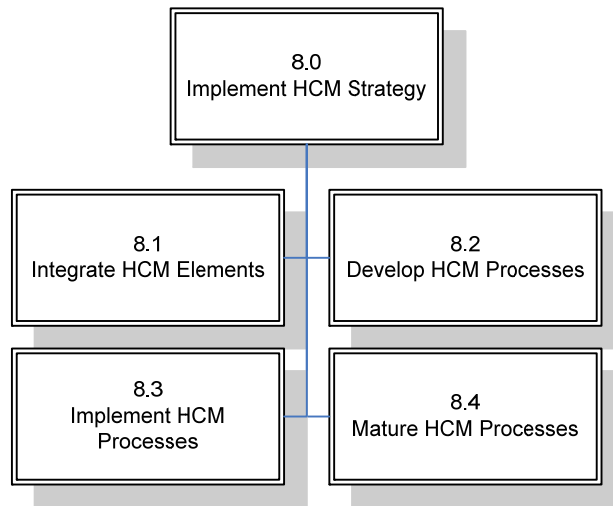


Figure 32. Decomposition of Top-Tier Function “Implement HCM Strategy.”

#### ***h. Function 9.0: Apply Proactive SME Development***

Figure 33 depicts the decomposition of top-tier Function 9.0, “Apply Proactive SME Development.” Applying a proactive approach to subject matter expert (SME) development leverages from the sub-function “Implement Technical Expertise Replenishment Strategy.” This top-tier function draws from the previous functions and applies them to the subsystem of SME development. To facilitate this function, identification of high potential individuals, nurturing them, and facilitating collaborative inter-agency (industry, government, and

academia) SME development must be achieved. Identification of high potential individuals is an internal action of the employer and functions to engage those individuals that can have the greatest potential impact to the DoD Shipbuilding technical disciplines. Once identified, these individuals are nurtured through specialized training and support. Such training and support should be coordinated between inter-agency entities so that SMEs from each agency are “grown” in parallel. The growth process could be achieved by the execution of inter-agency SME training and SME exchange programs. This action allows the SME to develop relationships across agencies to enhance and grow technical shipbuilding industry expertise.

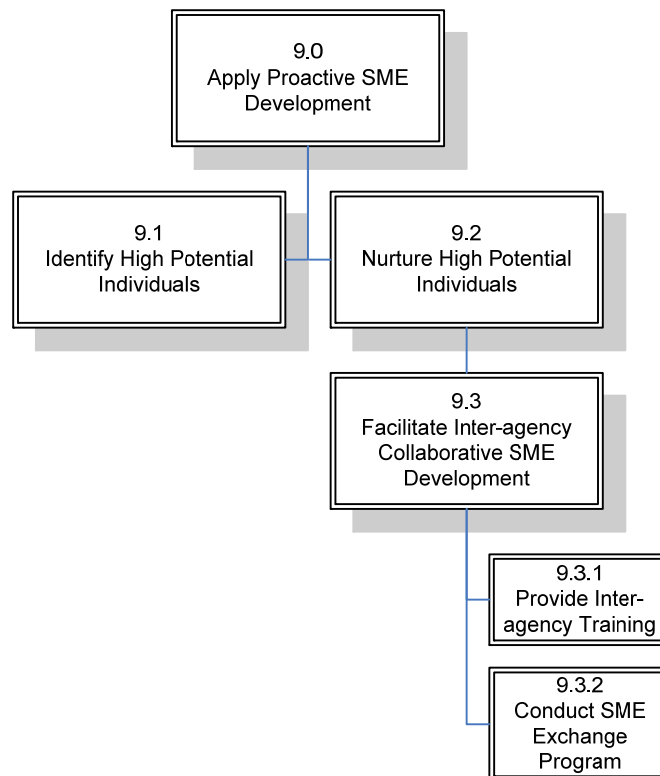


Figure 33. Decomposition of Top-Tier Function “Apply Proactive SME Development.”

***h. Function 10.0: Conduct Shipbuilding Opportunity Awareness Campaign***

Figure 34 depicts the decomposition of top-tier Function 10.0, “Conduct Shipbuilding Opportunity Awareness Campaign.” The activities for conducting a shipbuilding opportunity awareness campaign are characterized functionally by the engagement of non-traditional media outlets and maximizing the utilization of traditional shipbuilding media outlets. Generation Y (individuals born in the period 1976 to 2000) is set apart from previous generations because of their familiarity with computers and the internet. Due to this familiarity, Generation Y individuals are highly sought after for high tech job openings. Likewise, traditional media outlets (television, radio, billboards, etc.) may not be as effective in reaching this generation due to the amount of time they spend engaged in non-traditional media channels (video games, massive multiplayer online sites (MMO) and internet social sites such as Facebook, MySpace, YouTube, etc.). Therefore, it is imperative that the shipbuilding industry engage Generation Y individuals via these non-traditional media outlets to gain the visibility needed advertise the opportunities available in the industry. Methods of accomplishing this could be the creation of a shipbuilding video game where players create ships using mock-ups of current industry equipment (weapons, machinery, electrical, etc.) and pit their creations in simulated war games with other players. Another methodology that could be used is the creation of a shipyard social site where players create avatars (internet personas) that can meet to socialize while mimicking shipbuilding tasks like welding, painting, etc.

Even though the present generational talent pool does spend a considerable amount of time engaged in non-traditional media, traditional media efforts for reaching them should not be abandoned. Instead, utilization of these traditional media outlets should be maximized. This could be accomplished by first examining the effectiveness of these advertising methods (career days, community involvement, etc.) and using the data from the effectiveness study to

create a coordinated media awareness model. This model would ensure that all traditional media advertising outlets worked in an integrated fashion to deliver the message that technical opportunities in the shipbuilding industry is a viable career choice for Generation Y individuals.

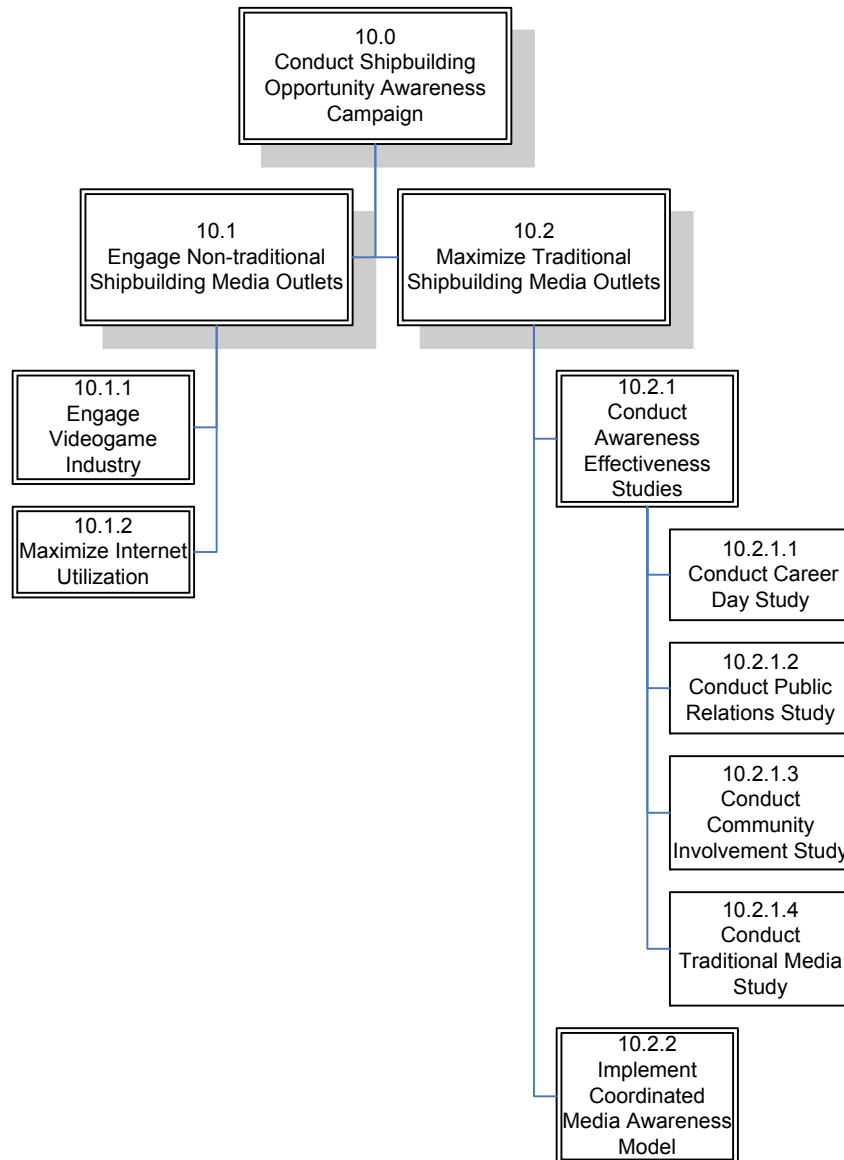


Figure 34. Decomposition of Top-Tier Function "Conduct Shipbuilding Opportunity Awareness Campaign."

#### **4. Customized System Architectures**

The Functional Decomposition presented in this chapter lists global functions for a notional HCM architecture that could be created for the DoD Shipbuilding Technical Industry. These functions are intended to provide a foundation for shipbuilding industry human capital managers to develop a customized HCM architecture for their particular organization. As stated in Chapter II:

According to Becker & Gerhart (1996) “There appears to be no best practice magic bullet short of organizing a firm’s HR system from a strategic perspective” (p. 797). In other words, a particular best practice feature would be incorporated as a property of the architecture of the system. These features must be aligned with the human capital system architecture to generate the desired improvement effect. The choice of which features to include depends on the circumstances and approaches undertaken by a particular firm.

Therefore, to ensure that an organization takes advantage of the maximum benefits of the Functional Analysis discussed in this chapter, the organization needs to review, customize, and decompose these global functions to third, fourth, fifth or sixth tier organization-specific functions using the global functions presented earlier as a roadmap.

Once the organization-specific functions are developed, the organization should create functional flow block diagrams (FFBD) that show how the functions mutually interact, similar in nature to a Use-Case Analysis. Such an analysis illuminates the physical and organizational resources that will be required to realize the mechanisms described in the HCM architecture (Blanchard & Fabrycky, 2006). Essentially, the FFBDs feed the design synthesis process in which the functional components are linked to top-level physical elements. The physical elements are then used to create alternative architectures for the HCM model. These alternatives easily lend themselves to evaluation to examine their effectiveness in meeting the stakeholder requirements. This is accomplished

using the overall measure of effectiveness (OMOE) model discussed later in this chapter. Once a particular architecture is selected, the system developer can proceed with the remaining Systems Engineering activities associated with concept level design.

## **B. OVERALL MEASURE OF EFFECTIVENESS MODEL**

The purpose of an overall measure of effectiveness (OMOE) model is to: (1) provide the decision-maker with a means to assess the difference in performance between multiple design configurations based on the choices of components in the design; (2) determine how well each component is judged to perform the system functions; and (3) determine how well each configuration meets the stakeholder's needs (Blanchard & Fabrycky, 2006; Whitcomb, 2008b). In this section, a notional OMOE model for the proposed HCM architecture is developed by means of an Analytic Hierarchy Process (AHP). The requirements derived from the stakeholder requirements determined in the analysis performed in Chapter III and the FA performed in the previous sections are used as attributes, which are ranked via pair-wise comparisons according to stakeholder preferences. These preferences are used to derive weights that feed the OMOE calculation (Whitcomb, 2008a).

### **1. HCM Value Hierarchy**

As the first step in the AHP, to guide the development of the OMOE model, a value hierarchy for the HCM Architecture is created, consisting of the stakeholder requirements, top-level functions, and design form elements. As shown in Figure 35, the value hierarchy indicates the relationship of the design form elements to the stakeholder needs they satisfy (Whitcomb, 2008a, 2008b). The stakeholder requirements depicted in the hierarchy are as described in Chapter III and the functional elements are derived from the prior functional analysis. Finally, the design form elements are grouped notionally into six general categories:

- Processes: Documented methodologies used in the architecture.
- Programs: The set of architecture instructions and/or services stakeholders execute upon request.
- Budgets: Monetary resources stakeholders use throughout the architecture's life cycle.
- People: These are the stakeholders with concerns related to the architecture.
- Facilities: Sites that integrate processes, people, programs, budgets and tools for the architecture.
- Tools: Devices stakeholders to implement architecture processes and/or programs.

Each form element represents a customization of these general forms based on the function supported and differs slightly depending on the related parent functions (Instituting Knowledge Management, Forming Industry-Government-Academia Partnerships, Providing Training, Interactive Recruiting, Talent Identification, Career Path Creation, Competitive Compensation, HCM Strategy Implementation, SME Development, and Increasing Industry Awareness).

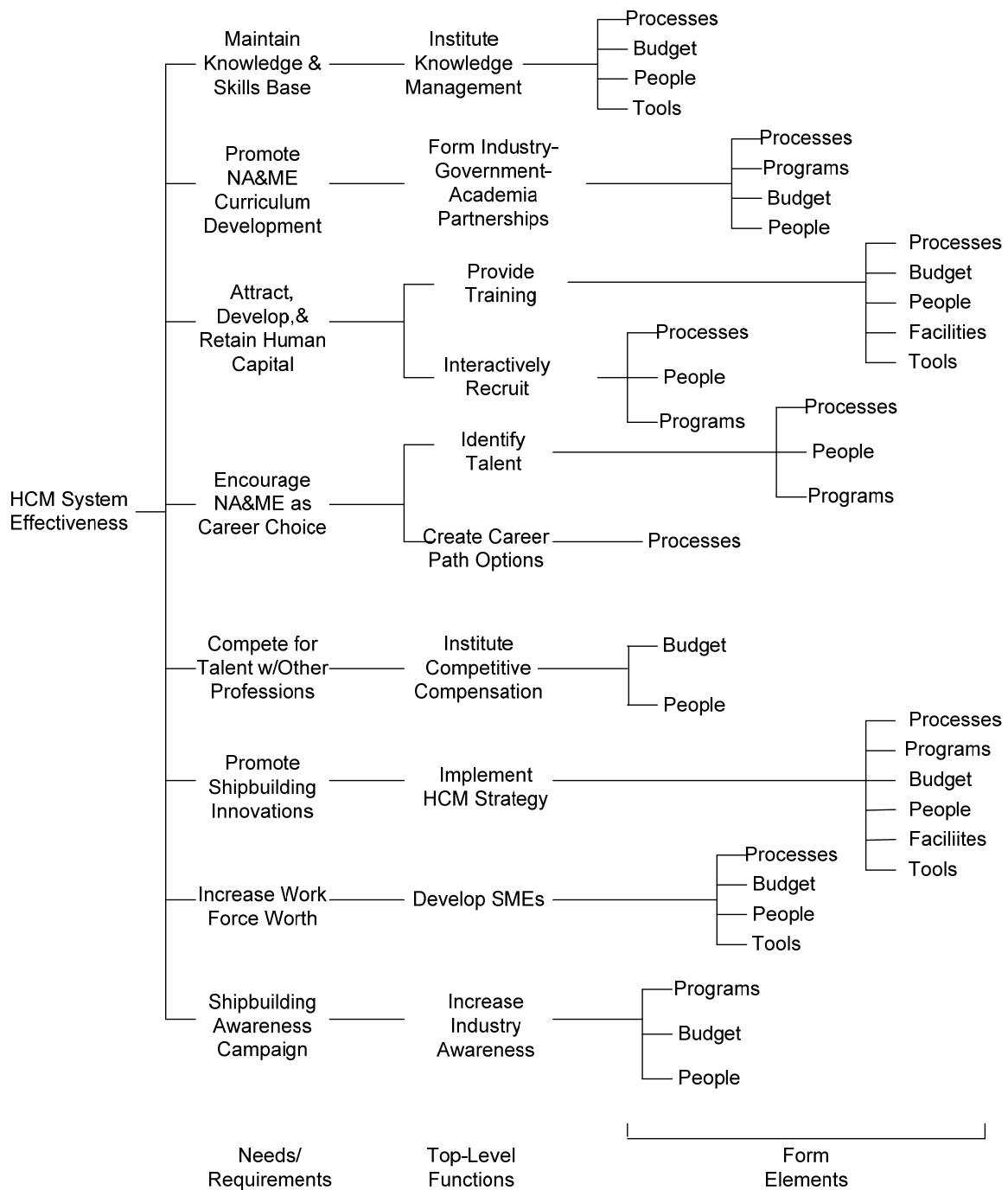


Figure 35. HCM Architecture Value Hierarchy



## 2. Prioritization of Stakeholder Requirements

The next step in the AHP analysis is to determine the priority of the stakeholder requirements. The requirements are prioritized to establish the relative importance of each requirement based on stakeholder preference. Issues may exist related to resource allocation for meeting the related need, or there may be conflicts between requirements that necessitate trade-off considerations. Thus, the stakeholder cannot have an equal priority for every requirement (Whitcomb, 2008a, 2008b).

To implement this portion of the model, the relative importance of the requirements is evaluated by performing a series of pair-wise comparisons. In each comparison, the stakeholder judges a given requirement in terms of how important it is relative to the others, indicating the degree to which a given requirement is favored over another (Whitcomb, 2008a). Table 21 shows this process as applied to the ten HCM architecture needs developed in Chapter III. In this example, the relative comparisons shown are subjectively determined based on the authors' knowledge gained during this research.

Top Level System Requirements	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase Awareness
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Promote NA&ME Curriculum Devel.
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Attract, Develop, Retain Human Capital
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Knowledge Transfer
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Knowledge Capture
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Promote Shipbuilding Innovations
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Encourage NA&ME as Career Choice
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Compete for Talent w/other professions
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase Worth of Technical Work Force

Table 21. Initial Pair-Wise Comparison of Stakeholder HCM Architecture Requirements Using Notional Requirements Scoring (After Whitcomb, 2008a).

In Table 21, the requirement “Maintain Knowledge and Skills Base” has been compared individually to the other nine requirements. When compared to “Increase Awareness,” the table indicates that the stakeholder slightly favors

maintaining the knowledge and skills base, scoring this comparison at a level of two. Had the stakeholder more strongly favored maintaining the skills base, a higher score would have been assessed. Conversely, if the priority favored the requirement “Increase Awareness,” the stakeholder would indicate the preference level (from two to nine) toward the right of the table. A value of one represents a neutral preference. That is, the stakeholder in this case does not favor one requirement in the pair over the other.

Next, this comparison is extended in matrix fashion to account for the comparisons for all other pairs of requirements, as shown in Figure 36. In the matrix, scores shown below the diagonal are inverses of those assessed above.

**Prioritization of Stakeholder Requirements via Pair-Wise Comparison**

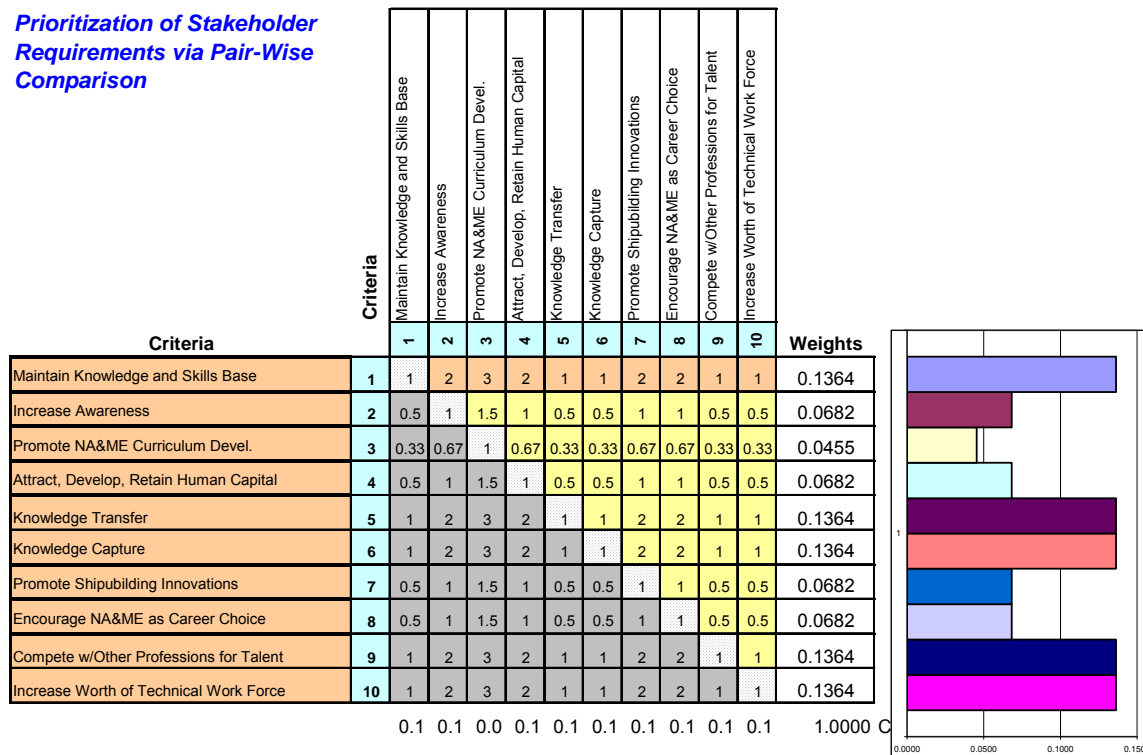


Figure 36. Pair-Wise Comparison Matrix for HCM Architecture Requirements Using Notional Requirements Scoring (After Whitcomb, 2008a).

Based on the set of paired comparisons, the weighted priority for each requirement is determined using the following formula:

$$Weight_i = \sum_{j=1}^m \left[ \frac{1}{m} \cdot \left( \frac{Score_j}{\sum_{i=1}^n Score_{ij}} \right) \right], \forall i, j \quad (5)$$

where,

$i$  = row index

$j$  = column index

$n$  = the number of rows

$m$  = the number of columns, and

$Score$  = the stakeholder's scoring for a given pair-wise comparison.

The resulting weights are indicated numerically and graphically to the right of Figure 36. Note that the values calculated in this analysis depict only a notional prioritization of the stated requirements and, as before, have been determined subjectively by the authors based on knowledge gained during research. In an actual application, a stakeholder may alter the scoring depending upon his or her own preferences or priorities. As seen in the table, the highest priority requirements are Maintain Knowledge and Skills Base, Knowledge Capture, Knowledge Transfer, Compete for Talent with Other Professions, and Increase the Worth of the Technical Work force.

### 3. Quality Function Deployment

Having prioritized the stakeholder requirements, the next step is to flow them down through a hierarchy of Quality Function Deployment (QFD) matrices, also known as Houses of Quality (HOQs). This portion of the analysis facilitates an understanding of the degree to which a chosen system configuration (choices

of form for the individual system elements), via the functional decomposition and design characteristics, reflects the degree of satisfaction of the stakeholder requirements. This is a prerequisite step in the examination of alternative system configurations. The flow down employed in this analysis consists of a set of three linked HOQs as depicted in Figure 37. In each HOQ, the customer requirements represent the “whats” (i.e., what the customer needs or requires) and are entered along the vertical. The attributes associated with the design are entered along the horizontal. These attributes represent the “hows,” or, the technical means by which the need or requirement is satisfied (Wollover, 1997; Moretto, 2006; Lowe & Ridgway, 2007; Whitcomb, 2008).

In the center of each HOQ, the relationship between the requirements and design attributes is investigated. Each attribute is scored according to the stakeholder’s judgment regarding the degree to which the attribute satisfies a given requirement. According to Whitcomb (2008a), typically the scoring is assessed using the following scale:

- 9 points: The attribute has a strong influence on satisfaction of the need/requirement.
- 3 points: The attribute has a moderate influence on satisfaction of the need/requirement.
- 1 point: The attribute has a weak influence on satisfaction of the need/requirement.

In this fashion, stakeholders indicate their subjective evaluations. At the bottom of the HOQ, the relative influence of each attribute is calculated in terms of a weighting determined from the sum-product of the assessed scores and the requirement weightings determined in the previous step, normalized on a percentage basis.



is performed in the same manner, using the top-level functions as the “whats” and the aspects of form that will perform the function in the system aligned on the horizontal as the “hows.” Through the linking of each HOQ, a set of weights is determined for the elements of form within the system, based on a particular prioritization of stakeholder requirements and needs. The utility of this method is that it allows the stakeholders to trace the effect of their preferences on the system elements and provide insight into the configuration choices that will realize their desires (Wollover, 1997; Moretto, 2006; Lowe & Ridgway, 2007; Whitcomb, 2008a, 2008b).

Continuing with the notional example applied to the HCM architecture, the stakeholder requirements and their weights (from Figure 36) are shown in the first level QFD matrix in Figure 38. Due to the similarity in nature and weighting of the “Maintain Knowledge and Skills Base,” “Knowledge Capture,” and “Knowledge Transfer” requirements, these three requirements have been combined into a single requirement labeled as “Maintain Knowledge and Skills Base.”

There are ten design characteristics used for comparison at this level, which are described as follows:

- Motivate—Encourage stakeholders to participate in the realization of the architecture.
- Cultivate—Nurture and grow human capital through continuous improvement of the architecture.
- Shape—Pertains to the molding of stakeholder thought processes and of perceptions of the architecture.
- Implement—Engage stakeholders of the architecture to act to apply the elements and processes described in the architecture.
- Recruit—Attract human capital to the shipbuilding industry via the architecture.
- Retain—Fasten stakeholders and human capital to the shipbuilding industry via the architecture.

- Manage—Supervise architecture development and implementation
- Develop—Enhancement of human capital in the shipbuilding industry through creation and maturation of the architecture.
- Invest—Secure the necessary financial resources to support stakeholders and implementation and sustainment of the architecture.
- Sustain—Support continued application of the architecture by continuously supporting stakeholder needs and requirements throughout the architecture's life cycle.

Scoring for the contribution of each of these characteristics to achievement of the stakeholder requirements is indicated as shown in Figure 38 and again, is a subjective judgment made by the authors based on knowledge gained during this research.

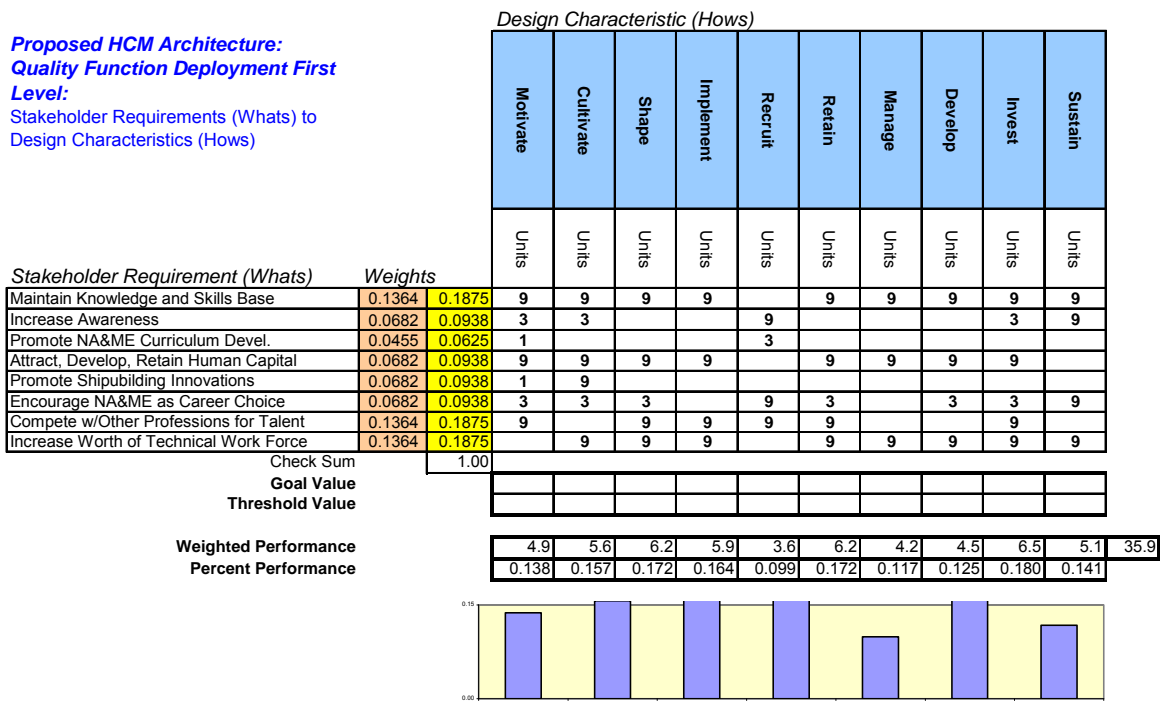


Figure 38. First Level QFD Matrix for Comparison of Top-Level Stakeholder Requirements to HCM Architecture Design Attributes (After Whitcomb, 2008b).

The process continues with a flow down of the first QFD matrix, aligning the design characteristics described above with the top-level functions described in the previous sections of this chapter. Figure 39 indicates the results of the scoring at this level.

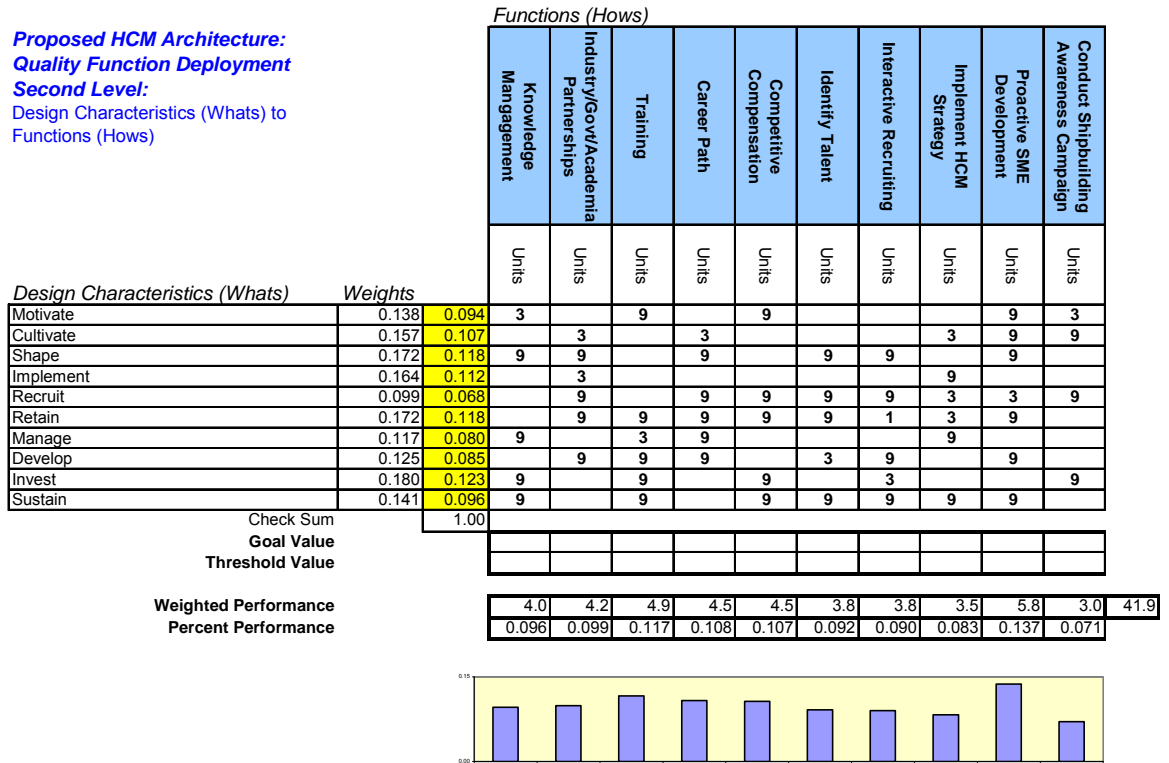


Figure 39. Second Level QFD Matrix for Comparison of HCM Architecture Design Attributes to Top Level HCM Architecture Functions (After Whitcomb, 2008b).

Finally, the third level QFD matrix aligns the top-level functions with elements of form that will perform these functions in a HCM system. The results of the QFD scoring at this third level are shown in Figure 40 and Figure 41, and are used in the next phase of the OMOE model development, the determination of the OMOE.



**Proposed HCM Architecture:  
Quality Function Deployment  
Third Level:**  
Functions (Whats) to Form (Hows)

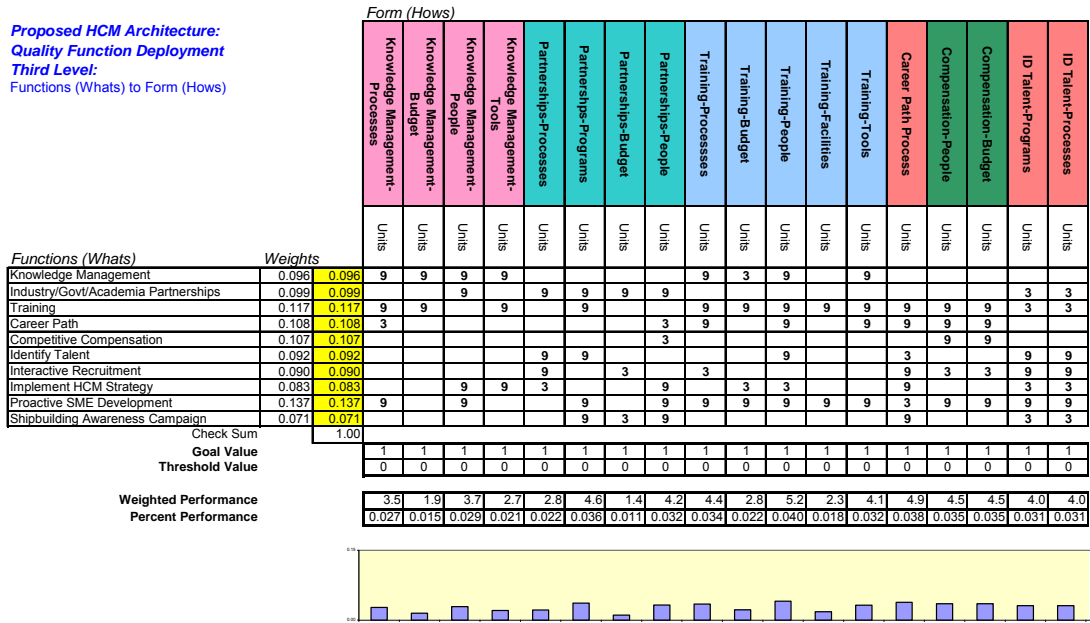


Figure 40. Third Level QFD Matrix for Comparison of HCM Architecture Design Attributes to Top Level HCM Architecture Functions, Part 1 (After Whitcomb, 2008b).

**Proposed HCM Architecture:  
Quality Function Deployment  
Third Level:**  
Functions (Whats) to Form (Hows)

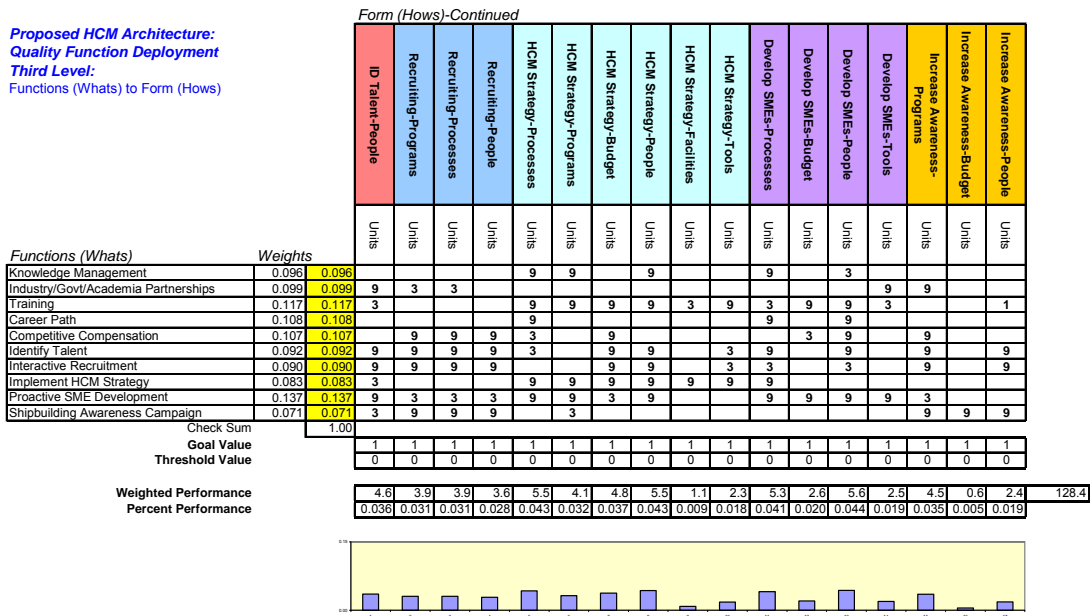


Figure 41. Third Level QFD Matrix for Comparison of HCM Architecture Design Attributes to Top Level HCM Architecture Functions, Part 2 (After Whitcomb, 2008b).

#### **4. OMOE Model**

The purpose of creating an OMOE model is to assign metrics to design form elements within the system in order to trace the effects of the performance of each element in the system back to the stakeholder requirements. By doing so, the stakeholder can examine how variations in the design form elements affect the ability of the system to meet the stated needs. This determination results in a single metric, the OMOE, which allows comparison of the effectiveness of one system configuration compared to others (Whitcomb, 2008b). To perform the OMOE analysis, a spreadsheet model created by NPS Professor Cliff Whitcomb (2008b) is used. In the model, the OMOE is calculated in five steps, as follows:

1. Determine the relationship between the form elements and the HCM architecture top-level requirements by mapping them in a value hierarchy. In the hierarchy, each form element is assigned a measure of performance (MOP) parameter related to the degree of its individual performance. Each stakeholder requirement is established as a measure of effectiveness (MOE) metric for the system, comprised of the aggregated effects of the MOPs for the individual elements, and serves to link the MOPs to the top-level system functions.
2. Determine the contributions of the individual form elements to each MOE by computing MOP scores based on stakeholder judgments of performance relative to desired threshold and goal values.
3. Determine the total contribution of the individual MOPs to their associated MOE.
4. Determine the contribution of each MOE to the OMOE.
5. Compute the OMOE.

The application of these steps for creation of the OMOE for the proposed HCM architecture is discussed in the following subsections.

***a. Mapping Stakeholder Requirements to Form Elements***

The first step for creating the OMOE model is to map the customer requirements to the design forms that perform the functions that will satisfy the stakeholder requirements. This is satisfied through the HCM Architecture Value Hierarchy presented previously in Figure 35. To describe the performance of each design form element, a measure of performance (MOP) is assigned. MOPs are technical measures of interest to the stakeholder that specify the degree of performance of the element. A minimum acceptable level of performance and a desired level of performance, known as the threshold and goal values, respectively, bound the range for each MOP. It is expected that the form element will perform within this range, and by making variations in this level of performance, the stakeholder can alter the contribution of the element to the overall system effectiveness. Thus, the stakeholder gains insight into the influence on system effectiveness based on variations in the form elements (Whitcomb, 2008a).

Since many of the elements in the proposed HCM architecture are not measurable in traditional units, a utility score is used, ranging from values of zero, representing the minimum acceptable threshold (low level), to one (high level) in which the performance goal is fully met. Intermediate (or medium level) values are possible as well, which reflect that the element partially meets the performance goal. These intermediate values are based on SME judgment regarding the level of utility of a particular variation in the design form element (Whitcomb, 2008a). The decision to use utility functions in this analysis rather than traditional units (for example available budget in dollars) is due to the variation in threshold and goal values depending on the stakeholder's circumstances. The utility function allows a scaled assessment and makes the

model more generically applicable. The authors, based on knowledge gained during this research, assigned utility function profiles to each of the form elements as indicated in Table 22.

Attribute Scoring Table	Low	Medium	High
Knowledge Management-Programs	0	0.5	1.0
Knowledge Management-Budget	0	0.6	1.0
Knowledge Management-People	0	0.7	1.0
Knowledge Management-Tools	0	0.5	1.0
Awareness-People	0	0.7	1.0
Awareness-Budget	0	0.6	1.0
Awareness-Programs	0	0.5	1.0
Partnerships-Processes	0	0.8	1.0
Partnerships-Programs	0	0.5	1.0
Partnerships-Budget	0	0.6	1.0
Partnerships-People	0	0.7	1.0
Training-Processes	0	0.8	1.0
Training-Budget	0	0.6	1.0
Training-People	0	0.7	1.0
Training-Facilities	0	0.5	1.0
Training-Tools	0	0.5	1.0
Recruiting-Program	0	0.5	1.0
Recruiting-Process	0	0.8	1.0
Recruiting-People	0	0.7	1.0
HCM Strategy-Process	0	0.8	1.0
HCM Strategy-Program	0	0.5	1.0
HCM Strategy-Budget	0	0.6	1.0
HCM Strategy-People	0	0.7	1.0
HCM Strategy-Facilities	0	0.5	1.0
HCM Strategy-Tools	0	0.5	1.0
Career Path Process	0	0.8	1.0
ID Talent-Program	0	0.5	1.0
ID Talent-Process	0	0.8	1.0
ID Talent-People	0	0.7	1.0
Compensation-People	0	0.7	1.0
Compensation-Budget	0	0.6	1.0
Develop SMEs-Process	0	0.8	1.0
Develop SMEs-People	0	0.7	1.0
Develop SMEs-Budget	0	0.6	1.0
Develop SMEs-Tools	0	0.5	1.0

Table 22. Attribute Scoring Table for HCM Architecture Design Form Elements (After Whitcomb, 2008b).

#### ***b. Calculation of Form Element MOP Scores***

Having established the scoring scale, assessments of each element's performance, as determined by the stakeholder, are entered into the OMOE model. Using the Whitcomb (2008b) spreadsheet model, the established

form element scoring scale is entered into the model, showing the threshold, goal, and attained value (i.e., the level of performance as judged by the stakeholder). This is shown on the far right in Figure 42, which depicts the fragment of the OMOE model pertaining to the “Maintain Knowledge and Skills Base” requirement. The assessed score for the given attribute is determined by interpolation based on the threshold, goal, and attained values, indicated in the MOP Attribute Name column beneath each form element.

Overall MOE <sub>i</sub>		0.629					
MOE Weight	MOE Criteria Name	MOP Weight	MOP Attribute Name	MOP Threshold	MOP Goal	Attained	Remarks
		0.027	Knowledge Management-Programs	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
		0.027	0.5				
		0.015	Knowledge Management-Budget	0	1	0.6	Level L=0; Level M=0.60; Level H=1.0
		0.015	0.6				
	0.28						
0.1875	Maintain Knowledge and Skills Base	0.029	Knowledge Management-People	0	1	0.7	Level L=0; Level M=0.70; Level H=1.0
0.1364		0.029	0.7				
		0.021	Knowledge Management-Tools	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
		0.021	0.5				

Figure 42. Fragment of the HCM Architecture OMOE Model (After Whitcomb, 2008b).

**c. Determination of Form Element MOP Contributions to Stakeholder Requirement MOEs**

Formation of the OMOE model continues by applying the previously assessed element performance MOP scores with their weightings determined in the third level QFD analysis to establish their contribution to attainment of the stakeholder requirement MOEs. This is accomplished by combining the performance of the form elements, via a weighted sum-product, into a single MOE raw score, as follows:

$$MOE\ Score_{Raw} = \sum_{j=1}^m (MOP\ Score_j) \cdot (MOP\ Weight_j) \quad (6)$$

where,

$j$  = individual MOP

$m$  = the number MOPs associated with the given MOE

$MOP\ Score$  = MOP scoring determined from application of utility functions.

$MOP\ Weight$  = MOP weighting determined from the third level QFD matrix.

The results of this computation are shown in Figure 42 above the subject MOE in the MOE Criteria Name column.

**d. Determination of Contributions of Stakeholder Requirement MOEs to the OMOE**

The contribution of each MOE to the OMOE is determined by normalizing the MOE weights from the first level QFD matrix:

$$MOE\ Weight_{Normalized} = \frac{(MOE\ Weight)}{\sum_{i=1}^n (MOE\ Weight_i)} \quad (7)$$

where,

$i$  = individual MOE

$n$  = the number MOEs

$MOE\ Weight$  = MOE weighting determined from the first level QFD matrix.

This is indicated on the left side of Figure 42 as the bold red value in the MOE weight column. The first level QFD matrix weight is indicated below this value.

**e. Calculation of the OMOE**

The final step in the process is to calculate the OMOE as a sum product of the MOE raw scores and the normalized MOE weights determined in the two previous steps, as follows:

$$OMOE = \sum_{i=1}^n (MOE\ Score_{Raw,i}) \cdot (MOE\ Weight_{Normalized,i}) \quad (8)$$

where,

$i$  = individual MOE

$n$  = the number MOEs

OMOE =Overall Measure of Effectiveness.

The results of this calculation appear in the upper left corner of Figure 42. The magnitude of the OMOE represents the fraction of total possible system performance achieved by the chosen configuration of form elements at the given level of performance. For example, an OMOE value of 0.589 represents delivery of 58.9% of the possible performance based on the chosen configuration and range of performance for each form element. By altering the performance of each form element, the effect on the OMOE, and thus the degree to which the stakeholder's requirements are satisfied, is determined and allows comparisons of alternate system solutions.

***f. Determination of the OMOE for the Proposed HCM Architecture***

The OMOE procedure outlined above was applied to the proposed HCM architecture analyzed in the prior sections of this chapter. In the analysis, notional scoring was applied to show a representative evaluation of the architecture. As in the stakeholder analysis, the scoring was determined based on subjective judgments of the authors. Weightings were applied in accordance with the determinations in the QFD matrices shown in Figure 38 through Figure 41, which were based on this scoring. A summary of the scores, weights, and the calculated OMOE is presented in Table 23. The complete QFE and OMOE models are shown in Appendix F.

While the results suggest an OMOE of 0.629, or 62.9% of the maximum effectiveness of the proposed HCM system configuration, it is

emphasized that these numbers only represent the authors' subjective evaluation of the proposed HCM architecture. Assessments by one or more of the key stakeholders would likely generate different OMOE results. However, the tool has been presented in this fashion to illustrate the means by which the key stakeholders of this system could make their own evaluations regarding alternate HCM strategies. To the authors' knowledge, such a model did not exist prior to this analysis. It is not within the scope of this study to provide this analysis of alternatives, but to provide a foundation for future exploration of the topic of HCM within the shipbuilding industry.

<b>Overall Measure Of Effectiveness (OMOE):</b>		<b>0.629</b>			
<b>Top Level Stakeholder Requirement</b>	<b>MOE Weight</b>	<b>MOE Score</b>	<b>Attribute Name</b>	<b>MOP Weight</b>	<b>MOP Score</b>
Maintain Knowledge and Skills Base	0.1875	0.28	Knowledge Management-Programs	0.0271	0.50
			Knowledge Management-Budget	0.0149	0.60
			Knowledge Management-People	0.0291	0.70
			Knowledge Management-Tools	0.0207	0.50
Increase Awareness	0.0938	0.39	Awareness-People	0.0354	0.70
			Awareness-Budget	0.0049	0.60
			Awareness-Programs	0.0049	0.50
Promote NA&ME Curriculum Development	0.0625	1.03	Partnerships-Processes	0.0216	0.80
			Partnerships-Programs	0.0216	0.50
			Partnerships-Budget	0.0107	0.60
			Partnerships-People	0.0324	0.70
Attract, Develop, & Retain Human Capital	0.0938	1.43	Training-Processes	0.0324	0.80
			Training-Budget	0.0220	0.60
			Training-People	0.0405	0.70
			Training-Facilities	0.0178	0.50
			Training-Tools	0.0321	0.50
			Recruiting-Program	0.0307	0.50
			Recruiting-Process	0.0307	0.80
			Recruiting-People	0.0284	0.70
Promote Shipbuilding Innovations	0.0938	1.24	HCM Strategy-Process	0.0426	0.80
			HCM Strategy-Program	0.0320	0.50
			HCM Strategy-Budget	0.0374	0.60
			HCM Strategy-People	0.0431	0.70
			HCM Strategy-Facilities	0.0085	0.50
Encourage NA&ME as Career Choice	0.0938	1.02	HCM Strategy-Tools	0.0182	0.50
			Career Path Process	0.0382	0.80
			ID Talent-Program	0.0310	0.50
			ID Talent-Process	0.0310	0.80
Compete w/Other Professions for Talent	0.1875	0.24	ID Talent-People	0.0356	0.70
			Compensation-People	0.0350	0.70
Increase Worth of Technical Work Force	0.1875	0.44	Compensation-Budget	0.0350	0.60
			Develop SMEs-Process	0.0410	0.80
			Develop SMEs-People	0.0203	0.70
			Develop SMEs-Budget	0.0437	0.60
			Develop SMEs-Tools	0.0193	0.50

Table 23. Results of OMOE Assessment of the Proposed HCM Architecture



## **C. CHAPTER SUMMARY**

This chapter performed a Functional Analysis of a proposed architecture for managing human capital in the DoD shipbuilding industry. This analysis used the results from the analyses and discussions from the previous chapters (characteristics of human capital and human capital management, DoD shipbuilding industry stakeholder analysis, and DoD shipbuilding industry HCM gap analysis) to suggest the first and second tier functions of the architecture. Ten top-tier functions were derived, as follows:

- Function 1.0: Facilitate Knowledge Management
- Function 2.0: Manage Industry-Government-Academic Partnerships
- Function 3.0: Administer Appropriate Training
- Function 4.0: Develop Career Paths
- Function 5.0: Institute Competitive Compensation
- Function 6.0: Identify Potential Talent
- Function 7.0: Utilize Interactive Recruitment
- Function 8.0: Implement HCM Strategy
- Function 9.0: Apply Proactive SME Development
- Function 10.0: Conduct Shipbuilding Awareness Campaign

It is through the implementation of these global functions that the stakeholder HCM needs are addressed and are representative of a notional HCM functional architecture that can be tailored by customization and decomposition to lower levels to suit an individual stakeholder's priorities.

To illustrate the means by which such a tailored decomposition may be evaluated, an OMOE model was developed using AHP and QFD methods. These methods allow the stakeholders to prioritize their requirements and examine how changes to the requirement priorities and design form element performance levels within the system alter the effectiveness of the human capital management system.

Both the architecture and OMOE model are presented as notional frameworks from which to build a HCM system to suit the general needs of the stakeholders. As such, the results presented in this analysis provide the first iteration in the development of a HCM architecture for the DoD Shipbuilding industry. It is expected that future iterations of this framework would fine-tune the decomposition of the architecture and OMOE model to meet the priorities and realities of a particular stakeholder.

The methodology presented in this chapter has particular importance since it gives system developers the necessary tools to create the physical form of a HCM architecture. In traditional engineering design of systems, developers review customer requirements and transition directly to the matching of physical components to fulfill the requirements. This method works for simple systems, but as the complexity of systems increases, the effectiveness of the traditional engineering design methodology sharply declines. Therefore, to ensure proper design of highly complex systems, implementation of the methodology presented in this chapter is essential.

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## **VI. CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH**

### **A. CONCLUSIONS**

This chapter discusses the research questions presented in Chapter I and provides insight into the answers based on the knowledge resulting from the research conducted in Chapters II through V. Each question is evaluated individually. Recommendations for future research into the topic of human capital management in the shipbuilding industry are discussed at the conclusion of the chapter.

#### **1. Research Question I**

The first research question posed pertained to existing Human Capital Strategies:

What are the current DoD Human Capital Strategies for science and engineering expertise?

- Why were these strategies developed?
- How are these strategies implemented?
- Where are the gaps in these strategies?

Chapter II provided a detailed discussion of Human Capital Management, including an explanation of the concept of human capital and a dialogue concerning human capital strategic implications. The chapter describes the concepts of human capital and human capital management; their importance to organizational effectiveness; and how traditional ideas for personnel management have differed from these concepts. The premise of recent human capital management theory is that people are assets to the organization that can

be developed and improved through investment and progressive management. This is in contrast to the traditional view, which holds that the firm's employees are costs to be minimized.

Human capital is an integral element within engineering organizations and refers to the economic value derived from the knowledge, skills, and abilities (i.e., competencies) possessed by the organization's people. These unique competencies give the firm a competitive edge, differentiate it from its competitors and, due to its intangible nature, are hard to duplicate or buy. Thus, human capital creates more value than physical capital and is a strategic asset to the organization. The firm's human capital management structures facilitate the creation of value within the organization and its products through the effective employment of these unique skills. The means by which firms manage their human capital is most effective when it is aligned with the organization's strategic goals. As stated in Chapter II, inclusion of human capital considerations within the organization's strategic plan can enhance the strategic position of the firm and add value through improved quality and financial performance. Though these strategies are not always implemented at the proper organizational levels, they should be integrated with the strategic needs of the organization for long lasting effects to be realized.

The DoD Human Capital Strategies examined in this thesis were the People Capability Maturity Model, CIPS Strategic Human Capital Framework and GAO Strategic Human Capital Management Model. Not all firms are adept at managing their human capital, and most do not become so overnight. Each of the frameworks examined were developed to facilitate a firm's evolution from low maturity levels, consisting of ad hoc human capital practices, to high maturity levels in which the firm maximizes the use of its critical human assets and seeks to improve them continuously. The CIPS and GAO models are adaptations of

People CMM that have been tailored for use by government organizations as means to more effectively manage human capital and prevent its decay due to external and internal influences.

Through use of Gap Analysis conducted in Chapter IV, the following gaps were exposed in HCM architectures applied to the Shipbuilding Industry for science and engineering expertise:

- Knowledge Management
- Industry-Government-Academia Partnerships
- Development and Implementation of Training
- Career Path Development
- Competitive Compensation
- Identification of potential engineering and science talent at the secondary and post-secondary education levels
- Interactive recruitment of potential talent at the secondary and post-secondary education levels
- Implementation of a HCM strategy
- Proactive Development of Subject-Matter Experts (SMEs)
- Shipbuilding Opportunities Awareness

These gaps are driven by the specific threats and vulnerabilities confronting defense-related shipbuilding. The effect of military transformation, with its emphasis on design innovation, forces the large shipbuilding companies to re-think the nature of their human capital. This factor requires development of a different type of engineer than in the past. This new engineer will be required to think differently and possess a wider multidisciplinary view of shipbuilding—in essence, be more like a Systems Engineer. Compounding this necessity is the sporadic dynamic of the ship design-and-build cycle and its low-rate production nature. This dynamic makes it difficult for shipyards to develop and retain talent

between build-starts or new designs. This requires companies to develop means to train new engineers more quickly through knowledge capture and management processes, while providing incentives for current engineering talent to remain in the industry.

Additionally, a disparity exists between the goals of Industry, Government, and Academia with respect to the means by which the talent pool is replenished with new NA&ME graduates. Industry desires an engineer that is ready “out of the box” while the academic view favors research opportunities and providing students with a wide engineering background that will lay the foundations for career longevity. At the same time, students are not aware of the opportunities available to them in a NA&ME career, favoring engineering disciplines that are perceived to be both more exiting and financially rewarding. Thus, the development of shipbuilding talent faces stiff competition from more popular engineering disciplines for students, faculty, and research dollars. An effort is required to reach out to prospective talent at all educational levels, starting at the secondary and post-secondary (middle and high school) levels. This is best approached in concert by all three entities since all would benefit from a coordinated effort to increase awareness of the rewards of an NA&ME career and at the same time feed their own talent pool. At the same time that fewer engineers are entering the industry, large numbers of older engineers are retiring and taking the industry’s critical knowledge and skills with them. These weaknesses in the industry point to the need to attract, retain, and train new talent (including proactively targeting especially talented individuals with the potential to become SMEs) while capturing the skills and knowledge of the existing talent and transferring it to the next generation of engineers.

Businesses in today’s environment need to determine the critical skills and knowledge necessary to produce products that are competitive in the marketplace and fulfill customer needs. These skills, and the means by which they are developed and managed, should be linked to the strategic goals of the

business. In addition, organizations must take the initiative to continuously improve their human capital and adapt it based on changes in the business and political environment. If shipyards do not find a means to address the shortcomings of their HCM practices, they risk becoming irrelevant in the future marketplace as they fail to keep pace with change and increasing systems complexity. If so, the shipbuilding industrial base will erode, leaving the United States in an unfavorable position.

## **2. Research Question II**

The second question posed addressed the issue of improving the existing state of human capital strategy in DoD Shipbuilding through application of Systems Engineering processes and techniques:

How can current human capital strategies for the development, attraction, retention and management of competency and intellectual resources for science and engineering skills be improved by using Systems Engineering methodologies to examine stakeholder needs, identify gaps, and develop a notional functional model of a Shipbuilding Industry HCM architecture?

The authors conducted an initial Systems Engineering concept design effort that lays the foundation for the development of an effective HCM architecture for technical and engineering talent in the DoD Shipbuilding Industry. By utilizing Systems Engineering techniques and methodologies, current human capital strategies can be improved by ensuring that primary and secondary stakeholder inputs (and resultant needs and requirements) are incorporated and gaps in current strategies are closed. This occurs by transforming the derived requirements resulting from analysis of these factors into the functional characteristics of the HCM architecture. Additionally, the OMOE model presented in Chapter V shows how the application of AHP and QFD methods can facilitate the judgment of the effectiveness of the notional HCM architecture developed herein based on the priorities of the individual stakeholders. This



functional approach to system design is a top-down design philosophy shown to be more effective than the traditional bottom-up design approach utilized in present HCM architectural designs. The results presented in Chapter V are the essential first iteration in the development of a HCM architecture.

Why is the design of a proper HCM architecture for the shipbuilding industry important? Given a hypothetical scenario where the technical expertise within DoD Shipbuilding Industry has been depleted, what would be the result? First, national security would be affected since the design for new shipbuilding programs would have to rely on outsourcing to foreign entities. Second, the status of the United States as a superpower could be diminished due to the reliance of foreign resources. As is the case with the dependence on foreign sources for oil, the U.S. may find it difficult to control costs and maintain market superiority. Given the possibility of these results, the development of a HCM architecture for scientific and engineering human capital in the DoD Shipbuilding Industry is vital to security and well-being of our nation. The application of a HCM architecture would provide a structured means to address HCM shortcomings within the industry before such dire circumstances could result.

### **3. Research Question III**

The final question posed regarded the comparison of the proposed HCM architecture with the current DoD Shipbuilding Industry HCM efforts:

How does this notional architecture compare with current DoD Human Capital Management efforts?

- How are these architectures comparable?
  - Does the notional architecture utilize components of current strategies?
  - Does the notional architecture address Stakeholder Needs?

- Primary Needs
- Latent Needs
- Do the notional architectures close the gaps identified in current DoD Human Capital Management Strategies?
- How might the effectiveness of this notional architecture be addressed?

The notional functional model presented herein compares with current HCM strategies by implementing common features from the three strategies examined in Chapter II (People CMM, the CIPS framework, and the GAO model) into the Functional Analysis. Through the Stakeholder Analysis presented in Chapter III, stakeholder primary and latent needs were prioritized and requirements were developed based on the top-tier needs. The gaps in current HCM strategies as identified in Chapter IV, and methods for closing the gaps, were incorporated into the Functional Analysis performed in Chapter V. As noted above, an illustration of a method for assessing the effectiveness of the proposed HCM architecture was presented via the creation of an OMOE model based on the data gathered from Chapters II through V. The OMOE metric calculated in the model could be used as an evaluation and selection criterion once stakeholders create alternative HCM architectures are based on the Functional Decomposition.

The notional scoring performed by the authors yielded an OMOE of only 0.629, indicating that room for improvement exists, even in the proposed architecture. Still, this model provides a starting point from which to begin the evaluation of the effectiveness of a detailed HCM architecture. To the author's knowledge, no such means of evaluation exists for HCM strategies within the shipbuilding industry. Use of such a model will allow the developers to project

the effectiveness of the system during development, thus allowing changes to be made prior to incurring the cost of fixing incorrect implementation.

## **B. AREAS FOR FUTURE RESEARCH**

The authors have provided a firm foundation for the creation of a HCM architecture for the technical and engineering human capital in the DoD Shipbuilding Industry. This effort provides an initial step in a series of Systems Engineering activities necessary for the completion of a functioning HCM architecture. It is expected that this work will stimulate investigation into the means by which the proposed architecture can be tailored for individual stakeholder organizations based on their unique human capital needs and priorities. The following sections provide insights for further research on this topic.

### **1. Other Systems Engineering Design Phases**

The authors concentrated on the concept level design of a HCM architecture. In this phase, Stakeholder Analysis, Gap Analysis, Functional Analysis and Effectiveness Modeling were used to facilitate HCM architecture development. Following this methodology, an area of future research would be to follow the Systems Engineering design philosophy for the development of the HCM architecture through the remaining product design phases (preliminary, detail design, construction, and deployment). Such an effort would investigate how this notional architecture could be applied to aid development, evaluation, and refinement of active HCM architectures for technical and engineering human capital in DoD Shipbuilding Technical Industry based on individual stakeholder priorities.

## **2. Development of Blue Collar HCM Architecture**

This thesis provided an analysis for the development of a HCM architecture to address the depletion of science and engineering expertise in the DoD Shipbuilding Industry. As noted in Chapter II, different types of human capital require different management and development processes. There are unique needs associated with science and engineering stakeholders that may not apply to blue-collar stakeholders (trades and crafts) for the shipbuilding industry. These two types of human capital are different in nature and motivated by different goals. In addition, firms utilize them differently. Therefore, another area for future research could be to extend and apply the lessons learned from this thesis to perform an analysis for the development of a HCM architecture for craft and trade workers for the DoD Shipbuilding Industry.

## **3. Replace Notional Scoring with Industry-Expert Scoring**

Throughout this work, scoring and rating of the stakeholder analysis and the QFD and OMOE were determined based on the subjective judgment of the authors. Therefore, the classification and prioritization of the stakeholders and the calculation of the OMOE are notional. As a first step in a second iteration of the HCM architecture, further research might investigate population of these models with scoring and ratings based on the informed judgment of leaders and HCM managers within the shipbuilding industry. Such an effort would enhance the elicitation of stakeholder needs, the subsequent development of requirements, and the ultimate refinement of the proposed HCM architecture.

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## **APPENDIX A**

This appendix provides the full framework for implementing the Human Capital Management Framework developed by the Center for Innovation in Public Service (CIPS). CIPS developed the matrices shown on the following pages for each of the seven HCM focus areas analyzed: Recruitment and Hiring, Retention, Staff Development, Workforce Planning, Performance Management, Information Sharing, and Personnel Transaction Support. Each matrix displays the primary steps (and their sub-steps) as they apply at each of the four maturity levels, from people-averse to people-centric. As described in Chapter II, the matrix presents the questions an organization's management asks in a self-assessment regarding its maturity level related to its human capital management practices (Center for Innovation in Public Service, 2006).

HCM Framework Steps: Recruitment and Hiring

Strategy						Implementation				Results	
Mission	Values	Vision	Strategy	Goals and Objectives	Policies	Infrastructure	Organizational Ability	Organizational Commitment	Work Environment and Culture	Organizational Output	Mission Performance and Outcome
The agency's recruitment and hiring efforts are central to its efforts to improve its effectiveness.	The value of recruitment and hiring top candidates, and efforts to recruit and hire highly competitive professionals, are central to the agency's mission.	Top candidates are identified, recruited, and hired in a timely manner (e.g., just-in-time hiring).	Recruiting and hiring top candidates are central to the agency's workforce planning strategy. The right candidates are hired at the right time for the most critical vacancies.	Top candidates are identified, recruited, and hired for critical positions across the agency. Recruitment and hiring objectives are regularly evaluated, with results available to all agency employees.	Rules and policies are implemented to ensure that top candidates are identified, recruited, and hired to meet the agency's needs.	Systems and processes exist to ensure that top candidates are identified, hired, and placed in the right position at the right time.	Recruitment and hiring activities are adequately funded and staffed. Across the agency, employees are aware that efforts to identify, recruit, and hire top candidates are resulting in the right hires for the right jobs.	Leaders perceive that recruitment and hiring are critical to the mission. Across the agency, staff and hiring goals are assessed to ensure that they are met.	Employees perceive that the organizational ability to recruit and hire top candidates is a benefit to all staff; an attitude that contributes to morale and productivity.	The right people are hired at the right time for the most critical vacancies and the results of the hiring efforts are quantified and documented through performance metrics.	Due to leadership commitment and engagement of all staff, high-quality candidates are consistently hired for the right jobs at the right time.
The agency's recruitment and hiring efforts are important, but not central to the mission.	While recruitment and hiring of highly competitive candidates are valued in the agency, efforts are aligned with, but not central to, the agency's mission.	Top candidates are identified, recruited, and hired, but the process can be lengthy and/or can result in improper placement.	Significant improvement has been made in recruiting and hiring, but efforts to engage top candidates are not integrated with the overall agency mission.	Top candidates are recruited and hired, but not always at the right time or to fill critical needs. Recruitment and hiring objectives are tracked, but employees are not advised of results.	Rules and policies are implemented to ensure that top candidates are identified and recruited, but the employees are not always hired at the right time and/or for the right position.	Systems and processes exist to ensure that top candidates are identified and recruited, but many times these individuals are not hired at the right time and/or for the right position.	While funding and staffing for recruitment and hiring are adequate and top candidates are hired, the goal of filling the most critical vacancies in a timely fashion is not met.	Leaders and human resources staff recognize the need to meet hiring goals, but recruitment falls short of filling the most critical vacancies with the best available candidates.	While top candidates are recruited and hired, many employees feel more effort should be devoted to recruiting candidates whose skills more closely fit critical needs.	Most recruitment and hiring efforts are successful, and those that are not are analyzed through the use of performance metrics to identify weaknesses in recruitment and hiring staffing and/or processes.	There could be more consistent commitment of leaders and those that are not are engaged in recruitment and hiring efforts.
The importance of attracting, selecting, and hiring top candidates is recognized, but not linked with the agency's overall success.	The value of attracting, selecting, and hiring top candidates is communicated to employees but is not clearly related to the agency's mission.	Top candidates are identified and recruited, but fail to matriculate in a large percentage of cases.	While top candidates are identified and recruited, many of them do not matriculate.	Many appropriate candidates inquire about job openings, but some do not matriculate. Hiring goals and objectives are evaluated only intermittently.	Rules and policies ensure that top candidates are identified and recruited, but many candidates do not matriculate.	Systems and processes exist to identify and recruit top candidates, but many candidates do not matriculate.	Inefficient funding and staffing of human resources staff result in a shortfall in top-quality, timely hires.	While leaders and staff are generally aware that recruitment and hiring should be improved, there is a lack of attention to implementing those objectives.	Leaders and human resources staff make efforts to recruit candidates, but those efforts generally fail, decreasing morale and productivity.	Recruitment and hiring of top candidates are sometimes successful. Performance metrics are not used to locate and quantify weaknesses in recruitment and hiring training and processes; low output cannot be addressed.	Staged-up efforts by agency leaders and human resources staff, to align resources with workforce needs, are needed to generate the outcome of top-quality hiring for critical vacancies in a timely manner.
Recruiting and hiring top candidates are not considered important to the agency's mission.	The value of attracting, selecting, and hiring top candidates is not communicated within the agency.	Top candidates are not identified and/or recruited in an aggressive manner.	There is no strategy for recruiting and hiring outstanding candidates.	There are no clearly defined goals and objectives for recruiting and hiring top candidates.	Rules and policies are lacking to ensure that top candidates are identified and/or hired.	Systems and processes do not exist to identify, recruit, or hire top candidates.	Inadequate funding, staffing, and training of recruitment and hiring staff make it impossible to attract and maintain top quality staff.	There is a lack of commitment to recruiting and hiring of top candidates, as seen in the inadequate quality of recruiter staff, training, and monitoring systems.	Employees are frustrated about the lack of leadership attention to improving recruitment and hiring staffing and processes.	Recruitment and hiring goals are consistently not reached due to low levels of leadership attention to the need.	Recruitment and hiring are peripheral to the mission.
People-Centric						People-Aligned				People-Aware	
People-Centric						People-Aligned				People-Averse	

People-Centric

People-Aligned

People-Aware

People-Averse

Figure 43. CIPS HCM Framework Steps: Recruitment and Hiring Component (From CIPS, 2006)

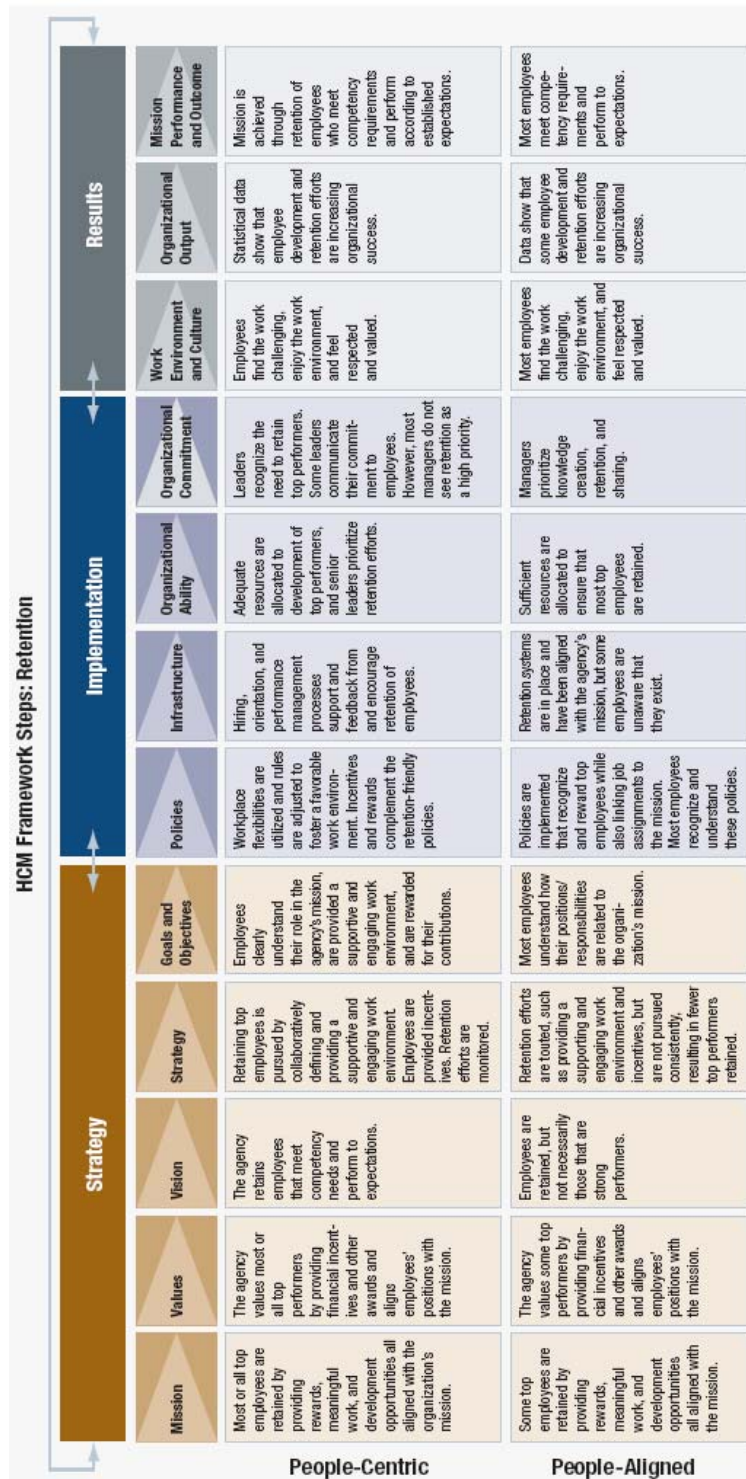


Figure 44. CIPS HCM Framework Steps: Retention Component (1 of 2) (From CIPS, 2006)





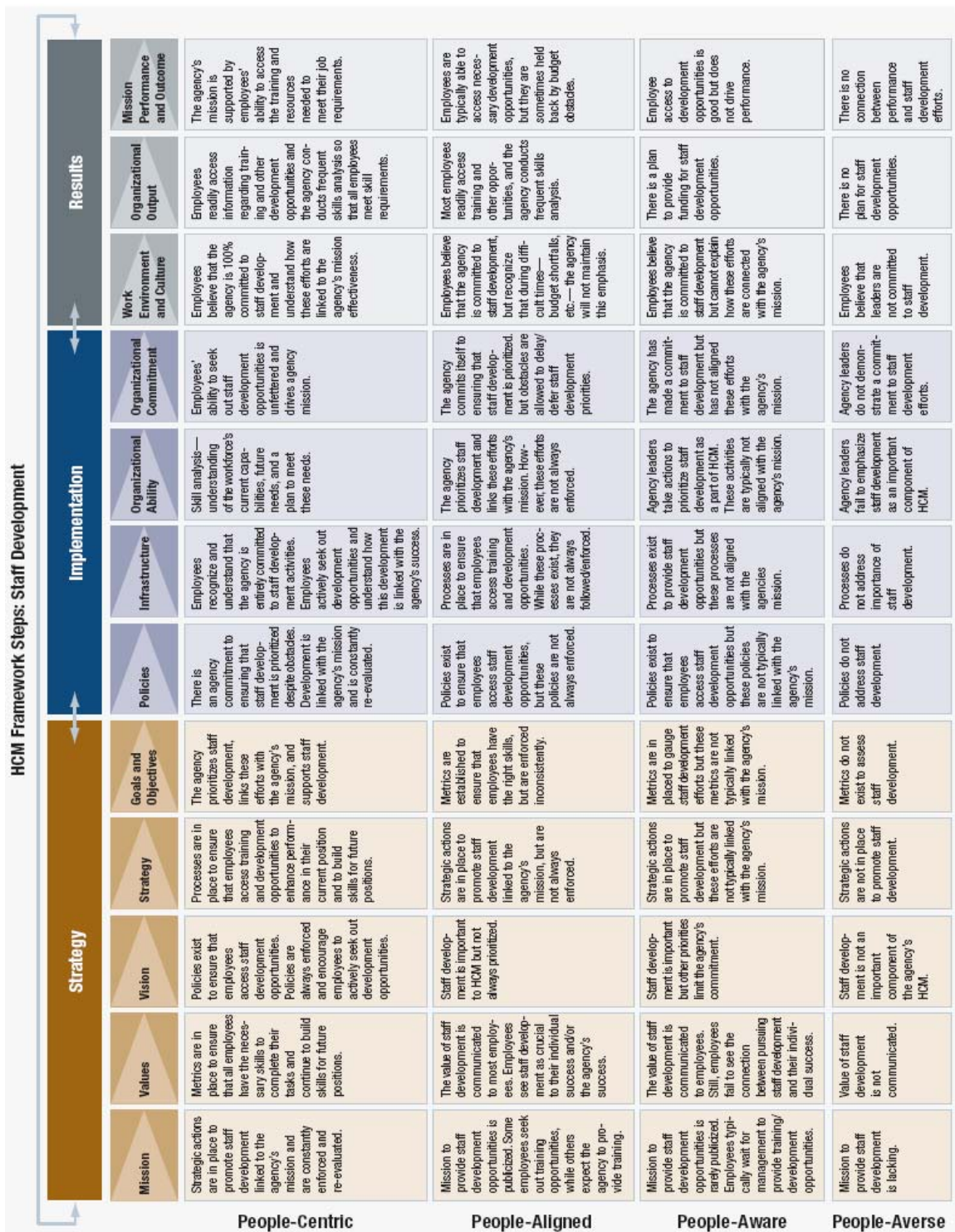


Figure 46. CIPS HCM Framework Steps: Staff Development Component (From CIPS, 2006)





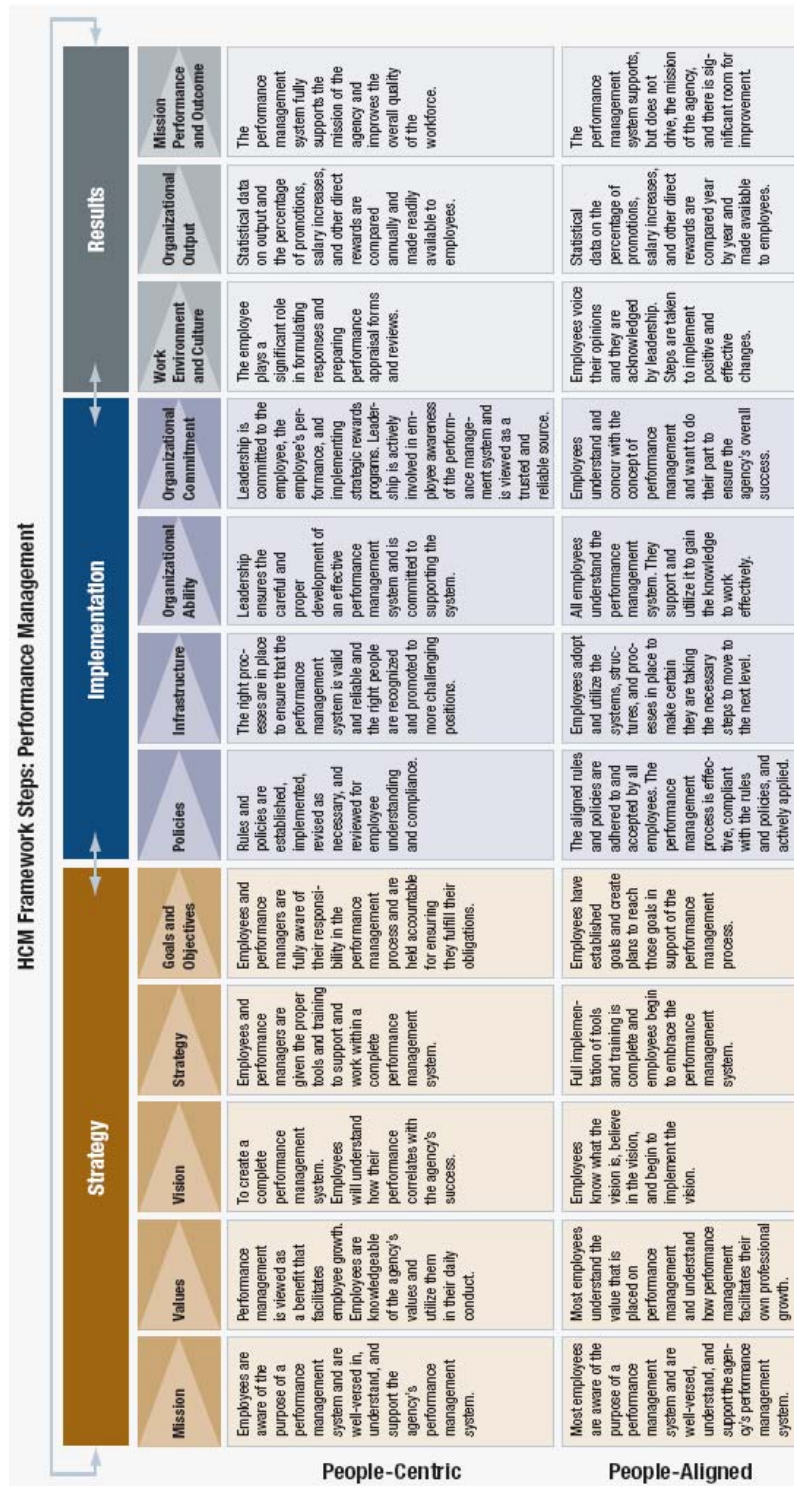


Figure 48. CIPS HCM Framework Steps: Performance Management Component (1 of 2) (From CIPS, 2006)

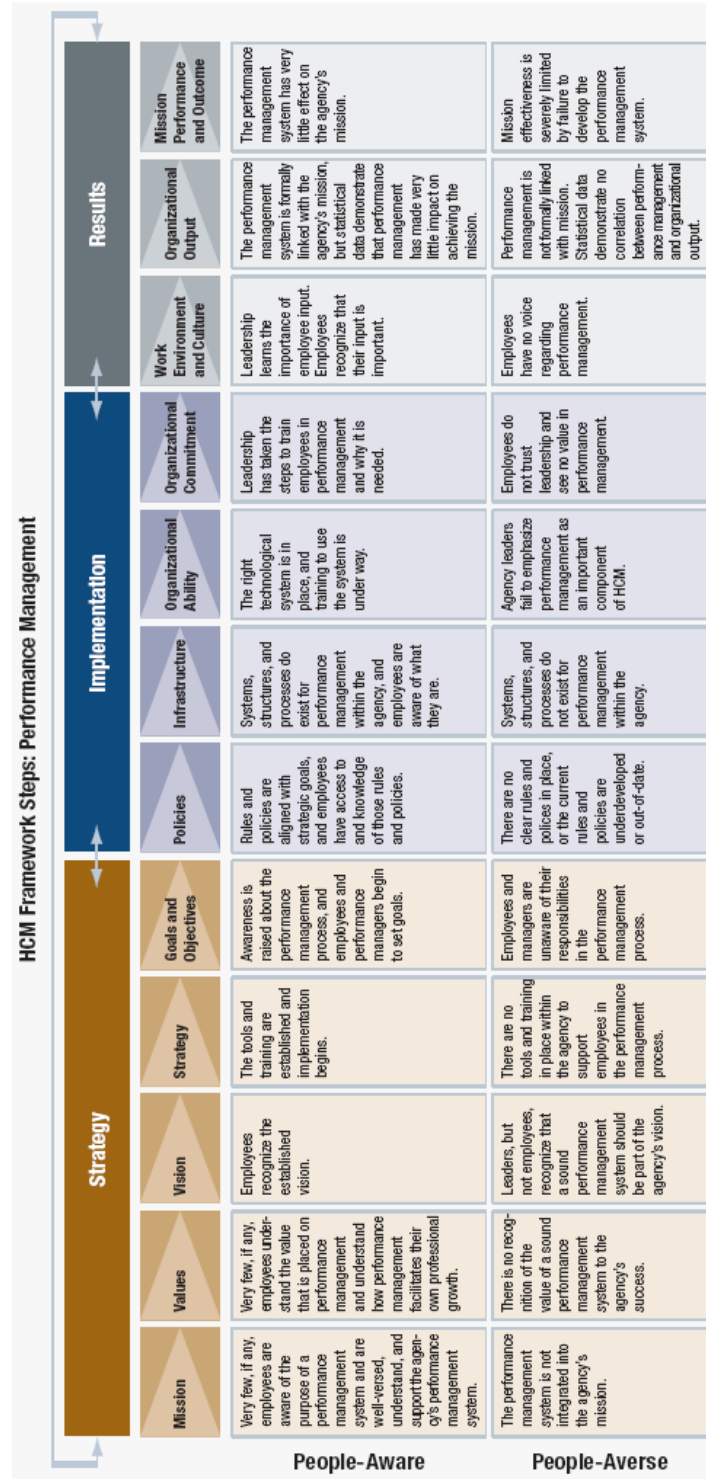


Figure 49. CIPS HCM Framework Steps: Performance Management Component (2 of 2) (From CIPS, 2006)



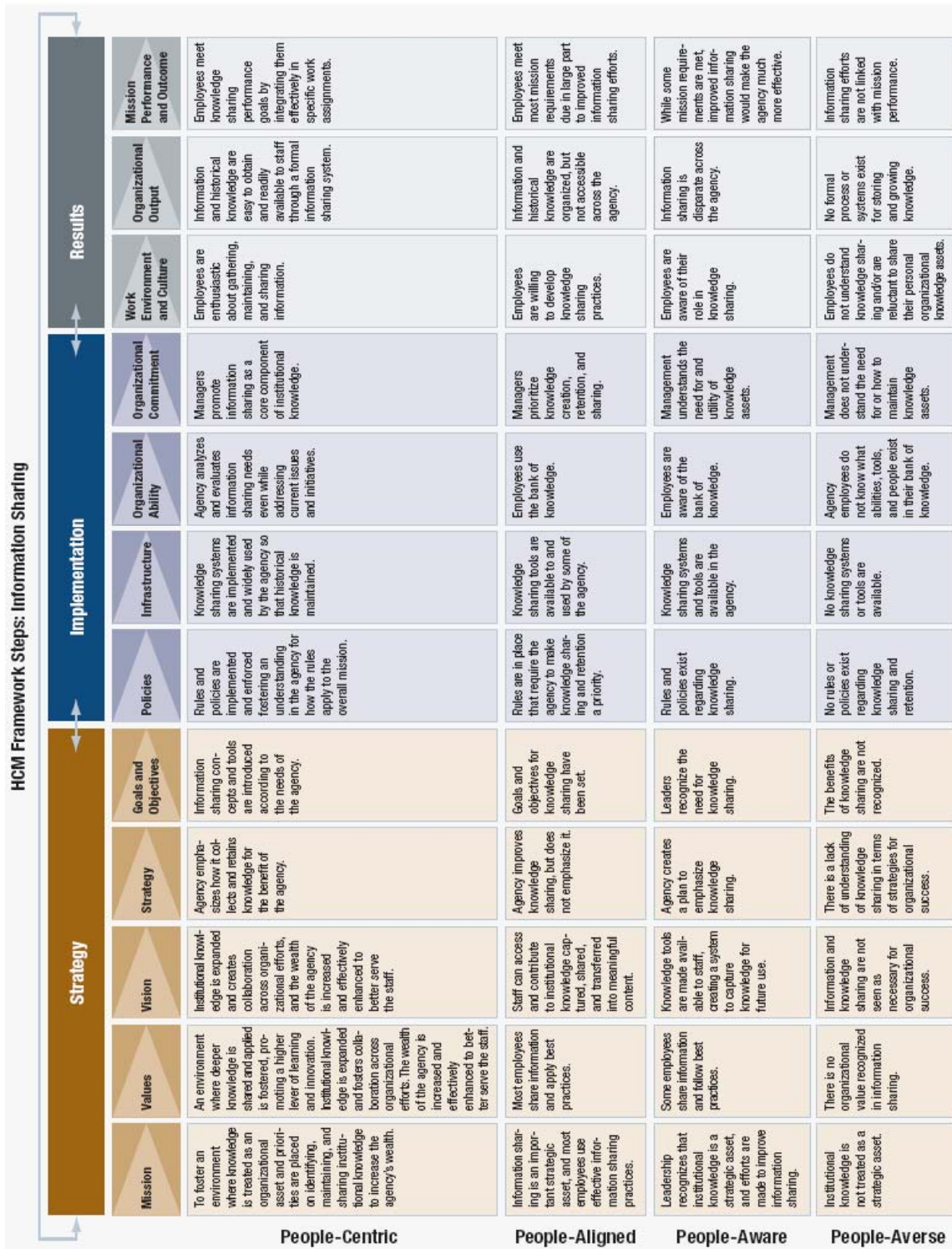


Figure 50. CIPS HCM Framework Steps: Information Sharing Component (From CIPS, 2006)

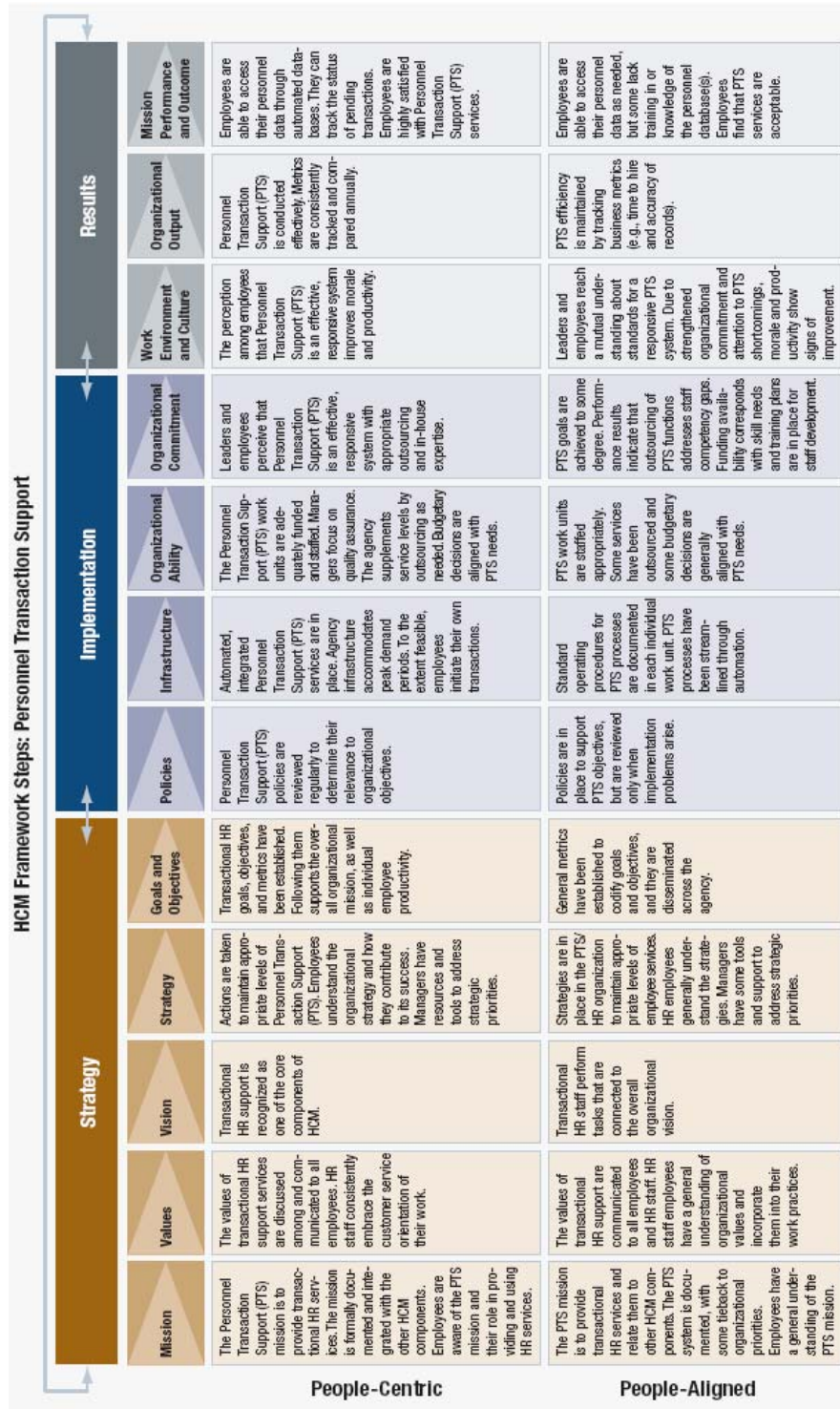


Figure 51. CIPS HCM Framework Steps: Personnel Transaction Support Component (1 of 2) (From CIPS, 2006)



Figure 52. CIPS HCM Framework Steps: Personnel Transaction Support Component (2 of 2) (From CIPS, 2006)



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## **APPENDIX B**

This appendix provides the full Critical Success Factors Table from the United States Government Accountability Office (GAO) report “*A Model of Strategic Human Capital Management*” published in 2002. The figures on the following pages describe the maturity level assessment criteria for each of the eight critical success factors developed in the GAO report. As described in Chapter II, GAO developed this model to provide a means for government agencies to assess their level of maturity in human capital management (GAO, 2002).



Figure 53. GAO Strategic Human Capital Management Framework Cornerstones and Critical Success Factors Structure (From GAO, 2002)

Human Capital Cornerstone Leadership			
Critical Success Factors	Level 1	Level 2	Level 3
<b>Commitment to Human Capital Management</b>	Agency leaders view people as costs to be cut rather than as assets to be valued. Management decisions involving the workforce are often made without considering how these decisions may affect mission accomplishment. Similarly, business decisions are often made without due consideration of the human capital needs they entail or the human capital approaches that may be needed for successful implementation.	Agency leaders acknowledge the importance of human capital to mission accomplishment, and have informed managers at all levels of the roles they need to play in acquiring, developing, and retaining people to meet the agency's programmatic needs. The agency is working to explicitly link its human capital approaches to intended program results.	Agency leaders view people as an important enabler of agency performance, recognize the need for sustained commitment by the agency to strategically manage its human capital, and stimulate and support efforts to integrate human capital approaches with organizational goals. The agency's human capital approaches are consistently developed, implemented, and evaluated by the standard of how well they support the agency's efforts to achieve program results. Managers at all levels actively support these concepts and are prepared and held accountable for effectively managing people.
<b>Role of the Human Capital Function</b>	Human capital management is considered a support function, separate from and generally subordinate to the agency's core planning and business activities. The "personnel" or "human resource management" office is largely process-oriented and focused on ensuring agency compliance with merit system rules and regulations. Expectations for staff in these offices are limited to processing transactions and addressing "personnel issues" on a case-by-case basis.	Human capital professionals have begun to focus on the agency's business needs and their role in filling them. The human capital function is in transition "from rules to tools," facilitating compliance with merit system principles and other national goals, and helping the agency more effectively meet its strategic and business goals. Human capital professionals are expected to be customer-oriented and to develop the expertise needed to be effective in their new roles.	Human capital professionals partner with agency leaders and line managers in developing strategic and program plans. The human capital office provides effective human capital strategies to meet the agency's current and future programmatic needs and fulfill merit systems principles and other national goals. Human capital professionals are prepared, expected, and empowered to provide a range of technical and consultative services to their internal customers; agency leaders and managers consistently recognize the key role of human capital professionals in helping the agency and its people effectively pursue their mission. The agency has streamlined personnel processes and effectively employs technology to meet customer needs.

Figure 54. GAO Strategic Human Capital Management Framework Critical Success Factors Table, Leadership Cornerstone (From GAO, 2002)

Human Capital Cornerstone			
Strategic Human Capital Planning			
Critical Success Factors	Level 1	Level 2	Level 3
Integration and Alignment	The agency has yet to fully recognize the link between its human capital approaches and organizational performance objectives. Existing human capital approaches have yet to be assessed in light of current and emerging agency needs. The agency changes or adopts human capital approaches without considering how well they support organizational goals and strategies, or how these approaches may be interrelated.	The agency's human capital needs are considered during strategic and annual planning. Existing human capital approaches have been assessed for their alignment with current and emerging needs. New human capital initiatives are in design or implementation specifically to support programmatic goals. These initiatives are building towards a coherent, results-oriented human capital program.	The agency's human capital approaches demonstrably support organizational performance objectives. The agency considers further human capital initiatives or refinements in light of both changing organizational needs and the demonstrated successes or shortcomings of its human capital efforts. The human capital needs of the organization and new initiatives or refinements to existing human capital approaches are reflected in strategic workforce planning documents.
Data-Driven Human Capital Decisions	Decisionmakers lack critical information with which to create a profile of the workforce (e.g., skills mix, deployment, and demographic trends) or to evaluate the effectiveness of human capital approaches, partially due to inadequate data sources. Performance measures and goals for the agency's human capital programs, especially as they link to programmatic outcomes, have yet to be identified.	The agency is working to ensure that information systems are in place to generate meaningful and reliable data across a range of human capital activities. Data gathered includes workforce shape, competencies and skills mix, and demographic trends. The agency has profiled its workforce so that usable information is on hand with which to make decisions in such areas as acquiring, developing, and retaining talent. The agency has identified performance measures and goals for its human capital programs, with attention to establishing the link between these programs and agency results.	Decisions involving human capital management and its link to agency results are routinely informed by complete, valid, and reliable data. Data gathered is kept current. Agency leaders use this information to manage risk by spotlighting areas for attention before crises develop and to identify opportunities for improving agency results. Performance measures for the agency's human capital programs have been distilled to a vital few, and are an integral part of the agency's strategic planning, performance measurement, and evaluation efforts. Data on the agency's workforce profile, performance goals and measures for human capital approaches, and areas requiring agency attention are reflected in strategic workforce planning documents.

Figure 55. GAO Strategic Human Capital Management Framework Critical Success Factors Table, Strategic Human Capital Planning Cornerstone (From GAO, 2002)

Human Capital Cornerstone			
Acquiring, Developing, and Retaining Talent			
Critical Success Factors	Level 1	Level 2	Level 3
Targeted Investments in People	Agency leaders approach human capital expenditures (e.g., professional development and knowledge management, recruiting programs, pay and benefits, performance incentives, and enabling technology) as costs that should be minimized rather than as investments that should be managed to maximize value while minimizing risk. Funding decisions may be ad hoc, without clearly defined objectives or adequate consideration of their implications for the workforce.	Human capital expenditures are regarded as investments in people and in the agency's capacity to perform its mission. Investment strategies for acquiring, developing, and retaining staff are evaluated and developed in light of modern human capital management practices.	Agency strategies for investing in human capital are fully integrated with needs identified through its strategic and annual planning. The goals and expectations for these investments are transparent and clearly defined, and their rationale is consistent across the range of human capital programs. The efficiency of the investments is continuously monitored and the effectiveness is periodically evaluated.
Human Capital Approaches Tailored to Meet Organizational Needs	Agency managers believe that meaningful improvements in human capital management are not feasible. The range of tools and flexibilities available to the agency under current laws and regulations have yet to be explored. In addition, the department or agency may have self-imposed constraints in place that are excessively process-oriented or based on obsolete perceptions of civil service laws, rules, or regulations.	Standardization and by-the-book human capital management are yielding to flexible and innovative approaches. Managers have identified the tools and flexibilities available to them under current law and are using many of these to modernize their human capital approaches to help meet current and emerging needs. The agency is looking for model principles and practices, and is pursuing opportunities to test new and more results-oriented approaches.	The agency tailors its human capital strategies to meet its specific mission needs. As such, it is taking all appropriate administrative actions available to it under current laws, rules, and regulations. In addition, it is exploring opportunities to enhance its competitiveness as an employer and eliminate barriers to effective human capital management. If needed, this includes producing a compelling business case to support selected legislative initiatives.

Figure 56. GAO Strategic Human Capital Management Framework Critical Success Factors Table, Acquiring, Developing, and Retaining Talent Cornerstone (From GAO, 2002)

Human Capital Cornerstone			
Results-Oriented Organizational Cultures			
Critical Success Factors	Level 1	Level 2	Level 3
Empowerment and Inclusiveness	Managers and staff rigidly adhere to standardized procedures and traditional modes of thinking. Human capital management in the agency is driven by top-down decision-making; relations between management and employees and their representatives are frequently more adversarial than is necessary. Substantial time and resources are consumed by reacting to workplace disputes and long-standing sources of conflict. The agency's approach to equal opportunity is compliance-oriented and reactive.	The agency is lessening its reliance on standardized approaches and encouraging program managers to innovate and take risks. Agency leaders are acknowledging the value of employee input and feedback to improve the workplace environment and focus on results; management and employee representatives stress communication and identify shared interests. The agency works to build a diverse workforce and has declared "zero tolerance" of discrimination.	Managers, teams, and employees at all levels are given the authority they need to accomplish programmatic goals; innovation and problem-solving are encouraged. In developing approaches to managing the workforce, agency leaders seek out the views of employees at all levels and communication flows up and down the organization. Management and employee representatives work collaboratively to achieve organizational outcomes. The agency works to meet the needs of employees of all backgrounds, maintains "zero tolerance" of discrimination, strives actively to reduce the causes of workplace conflicts, and ensures that conflicts are addressed fairly and efficiently. The agency recognizes and demonstrates that an inclusive workforce is a competitive advantage for achieving results.
Unit and Individual Performance Linked to Organizational Goals	The organizational culture is hierarchical, process-oriented, stovepiped, and inwardly focused. Performance expectations for managers and staff are blurred by an unclear organizational mission and a lack of clearly defined and consistently communicated core values.	The agency has created the basis for employee expectations by defining and communicating its mission, core values, strategic goals and objectives, and business strategies. Expectations for managers are shifting from complying with detailed rules and procedures to accomplishing program goals. The agency's performance management and incentive systems are being designed and tested to make employees aware of their roles and responsibilities in helping the agency achieve its performance goals. Efforts are under way to enhance internal cooperation.	The organizational culture is results-oriented and externally focused. Individual performance management is fully integrated into the agency's organizational goals and is used as a basis for managing the organization. Managers are held accountable through performance management and rewards systems for achieving strategic goals and objectives, creating innovation, and supporting continuous improvement. Clearly defined, transparent, and consistently communicated performance expectations addressing a range of results/customer/employee issues are in place to rate, reward, and hold accountable employees and teams at all levels.

Figure 57. GAO Strategic Human Capital Management Framework Critical Success Factors Table, Results-Oriented Organizational Cultures Cornerstone (From GAO, 2002)

## **APPENDIX C**

This Appendix presents the list of stakeholders generated in the first steps of the stakeholder analysis conducted in Chapter III. In all, the lists contain 134 stakeholders divided into five parts, as follows:

- Table 24 and Table 25 present the list of 90 stakeholders determined during the initial brainstorming session.
- Table 26 presents the list of stakeholders determined from consideration of Scenario 1, Creation of the Next-Generation Integrated Power System Handbook.
- Table 27 presents the list of stakeholders determined from consideration of Scenario 2, Creation of a Collegiate Shipbuilding Program.
- Table 28 presents the list of stakeholders determined from consideration of Scenario 3, Shipbuilding Career-Day Events.
- Table 29 presents the list of stakeholders determined from consideration of Scenario 4, Post-Katrina Human Capital Management Plans to support current shipbuilding production schedules.



Stakeholder Category	Potential Stakeholders
Academia	All colleges and universities that offer accredited undergraduate engineering degrees in the US
	All colleges and universities that offer accredited graduate engineering degrees in the US
	All public and private secondary educational school systems in the US
	All technical colleges and universities that offer associate engineering degrees in the US
	All colleges and universities that offer specialty naval related degrees in the US
Industry	INCOSE - International Council On System Engineering
	ISO - International Organization for Standardization
	IEC - International Engineering Consortium
	IEEE - Institute of Electrical and Electronics Engineers
	ASNE - American Society of Naval Engineers
	SNAME - The Society of Naval Architects & Marine Engineers
	AIAA - American Institute of Aeronautics and Astronautics
	NASA - National Aeronautics & Space Administration
	ANSI - American National Standards Institute
	Electronic Industries Alliance
	All US shipyards
	US shipyard management
	Recruiting agencies
	All DoD contractors
	American Bureau of Shipping
	All shipyard contractors
	ASME - American Society of Mechanical Engineers
	Center for Innovation In Ship Design
	ASCE - American Society of Civil Engineers

Table 24. Initial List of Stakeholders Determined During Brainstorming (1 of 2)

Stakeholder Category	Potential Stakeholders
Government	Local city government entities
	PEO (Program Executive Office) all associated groups
	PMS all associated groups
	ESO - Electric Ship Office
	NSRP - National Shipbuilding Research Program
	Local state government entities
	DEPARTMENT OF THE NAVY
	DoD all associated groups
	Congress
	NAVSEA all associated groups
	USMC all associated groups
	Army all associated groups
	Air Force all associated groups
	DAU - Defense Acquisition University
	Department of Defense Architecture Framework
	Department of Energy
	NAVAL AIR SYSTEMS COMMAND
	SPACE AND NAVAL WARFARE SYSTEMS COMMAND
	NAVAL SUPPLY SYSTEMS COMMAND
	FAR - Federal Acquisition Regulation
	Naval Aviation Logistics Command Management Information System
	Naval Air Warfare Center Weapons Division
	Office of the Chief of Naval Operations
	Office of the Secretary of Defense
	Defense System Management College
	NSWC
	CIA - Central Intelligence Agency
	DIA - Defense Intelligence Agency
	Defense Information Systems Agency
	Defense Science Board
	Defense Threat Reduction Agency
	Federally Funded Research and Development Center
	Joint Forces Command
	National Security Agency
	Strategic Command
	Environmental Protection Agency
	General Accounting Office
	National Academy of Public Administration
	National Academy of Sciences
	National Research Council
	National Science Board
	National Science Foundation
	Office of Personnel Management
	U.S. Department of Education
	CDNSWC
	POTUS
	Government Labs
	U.S. Coast Guard (associated departments and leadership)
	Dept. of Homeland Security
	Defense Acquisition Review Board
Other	Taxpayers
	Students
	Professors
	Teachers
	Administrators
	Employees
	Parents
	Families of users
	Churches
	Civic Organizations
	Servicemen
	Ship buyers
	Investors
	Families of civil service engineers
	Families of shipyard workers
	Communities

Table 25. Initial List of Stakeholders Determined During Brainstorming (2 of 2)

Stakeholder Category	Potential Stakeholders
Academia	All colleges and universities that offer accredited undergraduate engineering degrees in the US
	All colleges and universities that offer accredited graduate engineering degrees in the US
	All technical colleges and universities that offer associate engineering degrees in the US
	All colleges and universities that offer specialty naval related degrees in the US
Industry	INCOSE - International Council On System Engineering
	ISO - International Organization for Standardization
	IEC - International Engineering Consortium
	IEEE - Institute of Electrical and Electronics Engineers
	ASNE - American Society of Naval Engineers
	ANSI - American National Standards Institute
	General Dynamics shipyards
	Northrop Grumman shipyards
	shipyard management
Government	American Bureau of Shipping
	PEO (Program Executive Office)
	PMS
	ESO - Electric Ship Office
	DEPARTMENT OF THE NAVY
	Congress
	NAVSEA
	USMC all associated groups
	NAVAL SUPPLY SYSTEMS COMMAND
	Office of the Chief of Naval Operations
	Office of the Secretary of Defense
	ESRDC
	ONR
Other	Taxpayers
	Students
	Professors
	Teachers
	Administators
	Employees
	Servicemen
	Ship buyers

Table 26. List of Stakeholders Determined During Consideration of Scenario

Stakeholder Category	Potential Stakeholders
Academia	University of Wisconsin-Marquette
	University of South Alabama
Industry	Bender Shipbuilding and Repair
	Office
	Northrop Grumman Shipbuilding-Gulf Coast
	Genoa Design International
	Gibbs & Cox, Murray & Associates
	ShipConstructor Software
	Art Anderson Associates
	Software Developers (Shipbuilding Tools)
Government	Local city government entities
	PEO (Program Executive Office) all associated groups
	PMS all associated groups
	NSRP - National Shipbuilding Research Program
	Local state government entities
	DEPARTMENT OF THE NAVY
	DoD all associated groups
	Congress
	NAVSEA all associated groups
	USMC all associated groups
	Office of the Chief of Naval Operations
	Office of the Secretary of Defense
Other	Taxpayers
	Students
	Professors
	Teachers
	Administrators
	Parents
	Investors
	Communities

Table 27. List of Stakeholders Determined During Consideration of Scenario

Stakeholder Category	Potential Stakeholders
Academia	Old Dominion University Research Foundation
Industry	Northrop Grumman Newport News
	Northrop Grumman Ship Systems
	Colonna's Shipyard
	Shipyard management
	Recruiting agencies
Government	Local city government entities
	PEO (Program Executive Office) all associated groups
	PMS all associated groups
	NSRP - National Shipbuilding Research Program
	Local state government entities
	DEPARTMENT OF THE NAVY
	DoD all associated groups
	Congress
	NAVSEA all associated groups
	Office of the Chief of Naval Operations
	Office of the Secretary of Defense
Other	Taxpayers
	Students
	Professors
	Teachers
	Administrators
	Parents
	Churches
	Civic Organizations
	Communities

Table 28. List of Stakeholders Determined During Consideration of Scenario

Stakeholder Category	Potential Stakeholders
Academia	Jackson County School System (Mississippi)
	George County School System (Mississippi)
	Harrison County School System (Mississippi)
	Mobile County School System (Alabama)
	Jefferson Parish School System (Louisiana)
	Naval Postgraduate School
	Virginia Tech
	Texas A&M
	University of Maryland
	Stephens Institute
	Jackson State University
	Mississippi State University
	Ohio University
	University of Illinois
	University of Southern Mississippi
	University of Mississippi
	Pennsylvania State University
	University of Delaware
	University of New Orleans
	University of South Alabama
Industry	INCOSE - International Council On System Engineering
	IEEE - Institute of Electrical and Electronics Engineers
	ASNE - American Society of Naval Engineers
	SNAME - The Society of Naval Architects & Marine Engineers
	Northrop Grumman - Gulf Coast Operations
	Recruiting agencies
	American Bureau of Shipping
	American Shipbuilding Association
	ASME - American Society of Mechanical Engineers
	ASCE - American Society of Civil Engineers
Government	Jackson County government entities (Mississippi)
	George County government entities (Mississippi)
	Harrison County government entities (Mississippi)
	Mobile County government entities (Alabama)
	Jefferson Parish government entities (Louisiana)
	PEO (Program Executive Office) all associated groups
	PMS all associated groups
	NSRP - National Shipbuilding Research Program
	Louisiana state government entities
	Mississippi state government entities
	Alabama state government entities
	DEPARTMENT OF THE NAVY
	DoD all associated groups
	Congress
	NAVSEA all associated groups
	USMC all associated groups
	Office of the Chief of Naval Operations
	Office of the Secretary of Defense
Other	U.S. Department of Education
	Dept. of Homeland Security
	Taxpayers
	Students
	Professors
	Teachers
	Administrators
	Employees
	Parents
	Churches
	Civic Organizations
	Communities

Table 29. List of Stakeholders Determined During Consideration of Scenario

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## APPENDIX D

This Appendix presents the full results of the stakeholder analysis performed in Chapter III. This data is presented in a series of tables, as follows:

- Table 30 through Table 33 present the results of the initial Classification of Stakeholders and their Impact to System Life Cycle Stages. The list consists of the 134 stakeholders determined during the brainstorming sessions and scenario investigations. One table is provided for each of four stakeholder categories: Academia, Industry, Government, and Other.
- Table 34 through Table 43 present the results of the Determination of Stakeholder Worth. Due to the large number of potential stakeholders, this table shows the pair-wise comparisons in ten sections:
  - Academia to Academia
  - Academia to Industry
  - Academia to Government
  - Academia to Other
  - Industry to Industry
  - Industry to Government
  - Industry to Other
  - Government to Government
  - Government to Other
  - Other to Other
- Table 44 through Table 47 present the Determination of Stakeholder Importance, Stakeholder Influence, and a final determination, based on scoring, of the Stakeholder Classification. One table is provided for each of four stakeholder categories: Academia, Industry, Government, and Other.



Stakeholder Category	Potential Stakeholders	Internal				First-Order			Second-Order			Product Life Cycle						
		Designers	Builders	Participants	Suppliers	System Providers	User	Adversaries	System Supporters	Customers	Competitors	Investors	Concept	Preliminary	Detail Design	Production	Deployment	Disposal
Academia	All colleges and universities that offer accredited undergraduate engineering degrees in the US											X					0.25	
	All colleges and universities that offer accredited graduate engineering degrees in the US											X					0.25	
	All public and private secondary educational school systems in the US											X					0.25	
	All technical colleges and universities that offer associate engineering degrees in the US											X					0.25	
	All colleges and universities that offer specialty naval related degrees in the US											X					0.25	
	University of South Alabama				X												0.25	
	Old Dominion University Research Foundation							X						0.25			0.25	
	University of Wisconsin-Marquette							X									0.25	
	Jackson County School System (Mississippi)				X												0.25	0.10
	George County School System (Mississippi)				X												0.25	0.10
	Harrison County School System (Mississippi)				X												0.25	0.10
	Mobile County School System (Alabama)				X												0.25	0.10
	Jefferson Parish School System (Louisiana)				X												0.25	0.10
	Naval Postgraduate School	X											1.00	0.75	0.50	0.25	0.25	0.10
	Virginia Tech								X								0.25	
	Texas A&M							X	X								0.25	
	University of Maryland							X	X								0.25	
	Stephens Institute							X	X								0.25	
	Jackson State University				X											0.25	0.25	
	Mississippi State University				X										0.25	0.25		
	Ohio University							X	X								0.25	
	University of Illinois							X	X								0.25	
	University of Southern Mississippi				X											0.25	0.25	
	University of Mississippi				X											0.25	0.25	
	Pennsylvania State University								X								0.25	
	University of Delaware								X								0.25	
	University of New Orleans					X											0.25	0.25

Table 30. Initial Classification of Stakeholders and Their Impact on System Lifecycle Stages, (1 of 4): Academia

Stakeholder Category	Potential Stakeholders	Internal				First-Order			Second-Order			Product Life Cycle						
		Designers	Builders	Participants	Suppliers	System Providers	User	Adversaries	System Supporters	Customers	Competitors	Investors	Concept	Preliminary	Detail Design	Production	Deployment	Disposal
Industry	INCOSE - International Council On System Engineering								X							0.25	0.25	0.10
	ISO - International Organization for Standardization										X						0.25	
	IEC - International Engineering Consortium										X						0.25	
	IEEE - Institute of Electrical and Electronics Engineers								X								0.25	
	ASNE - American Society of Naval Engineers								X						0.25	0.25	0.10	
	SNAME - The Society of Naval Architects & Marine Engineers								X							0.25	0.25	0.10
	AIAA - American Institute of Aeronautics and Astronautics									X							0.25	
	NASA - National Aeronautics & Space Administration									X							0.25	
	ANSI - American National Standards Institute										X						0.25	
	Electronic Industries Alliance											X					0.25	0.10
	All US shipyards										X						0.25	0.10
	US shipyard management					X									0.50	0.25	0.25	0.10
	Recruiting agencies							X									0.25	
	All DoD contractors						X										0.25	
	American Bureau of Shipping						X									0.25	0.25	0.10
	All shipyard contractors						X									0.25	0.25	0.10
	ASME - American Society of Mechanical Engineers							X									0.25	
	Center for Innovation In Ship Design			X											0.25	0.25	0.10	
	ASCE - American Society of Civil Engineers							X									0.25	
	General Dynamics shipyards										X						0.25	0.10
	Bender Shipbuilding and Repair											X					0.25	0.10
	Bollinger Shipyards																0.25	0.10
	Northrop Grumman Shipbuilding-Gulf Coast	X											1.00	0.75	0.50	0.25	0.25	0.10
	Genoa Design International										X						0.25	
	Gibbs & Cox, Murray & Associates										X						0.25	
	ShipConstructor Software									X							0.25	
	Art Anderson Associates											X					0.25	
	Software Developers (Shipbuilding Tools)									X							0.25	0.25
	Northrop Grumman Newport News		X														0.25	0.25
	Colonna's Shipyard										X						0.25	0.10
	American Shipbuilding Association				X										0.50	0.25	0.25	0.10

Table 31. Initial Classification of Stakeholders and Their Impact on System Lifecycle Stages, (2 of 4): Industry

Stakeholder Category	Potential Stakeholders	Internal				First-Order			Second-Order			Product Life Cycle						
		Designers	Builders	Participants	Suppliers	System Providers	User	Adversaries	System Supporters	Customers	Competitors	Investors	Concept	Preliminary	Detail Design	Production	Deployment	Disposal
Government	Local city government entities							X										0.25
	PEO (Program Executive Office) all associated groups				X											0.25	0.25	0.10
	PMS all associated groups				X											0.25	0.25	0.10
	ESO - Electric Ship Office				X													0.25
	NSRP - National Shipbuilding Research Program				X							0.75	0.50	0.25	0.25	0.10		
	Local state government entities							X										0.25
	DEPARTMENT OF THE NAVY				X								0.50	0.25		0.25	0.10	
	DoD all associated groups							X									0.25	0.10
	Congress							X									0.25	0.10
	NAVSEA all associated groups				X								0.75	0.50	0.25	0.25	0.10	
	USMC all associated groups										X							0.25
	Army all associated groups									X								0.25
	Air Force all associated groups									X								0.25
	DAU - Defense Acquisition University										X						0.25	0.10
	Department of Defense Architecture Framework										X							0.25
	Department of Energy									X								0.25
	NAVAL AIR SYSTEMS COMMAND										X							0.25
	SPACE AND NAVAL WARFARE SYSTEMS COMMAND										X							0.25
	NAVAL SUPPLY SYSTEMS COMMAND										X							0.25
	FAR - Federal Acquisition Regulation										X							0.25
	Naval Aviation Logistics Command Management Information System										X							0.25
	Naval Air Warfare Center Weapons Division										X							0.25
	Office of the Chief of Naval Operations							X					0.50	0.25	0.25	0.10		
	Office of the Secretary of Defense							X										0.25
	Defense System Management College										X							0.25
	NSWC										X							0.25
	CIA - Central Intelligence Agency										X							0.25
	DIA - Defense Intelligence Agency										X							0.25
	Defense Information Systems Agency										X							0.25
	Defense Science Board										X						0.25	0.10
	Defense Threat Reduction Agency										X							0.25
	Federally Funded Research and Development Center										X							0.25
	Joint Forces Command										X							0.25
	National Security Agency										X							0.25
	Strategic Command										X							0.25
	Environmental Protection Agency									X								0.25
	General Accounting Office										X					0.25	0.25	0.10
	National Academy of Public Administration										X							0.25
	National Academy of Sciences										X					0.25	0.25	0.10
	National Research Council										X					0.25	0.25	0.10
	National Science Board										X					0.25	0.25	0.10
	National Science Foundation										X					0.25	0.25	0.10
	Office of Personnel Management										X						0.25	
	U.S. Department of Education										X					0.25	0.25	0.10
	CDNSWC										X						0.25	
	POTUS										X						0.25	
	Government Labs							X									0.25	
	U.S. Coast Guard (associated departments and leadership)							X									0.25	0.10
	Dept. of Homeland Security							X									0.25	0.10
	Defense Acquisition Review Board										X						0.25	0.10
	ESRDC							X									0.25	0.10
	ONR				X												0.25	0.10
	Jackson County government entities (Mississippi)							X									0.25	0.10
	George County government entities (Mississippi)							X									0.25	0.10
	Harrison County government entities (Mississippi)							X									0.25	0.10
	Mobile County government entities (Alabama)							X									0.25	0.10
	Jefferson Parish government entities (Louisiana)							X									0.25	0.10
	Louisiana state government entities							X									0.25	0.10
	Mississippi state government entities							X									0.25	0.10
	Alabama state government entities							X									0.25	0.10

Table 32. Initial Classification of Stakeholders and Their Impact on System Lifecycle Stages, (3 of 4): Government

Stakeholder Category	Potential Stakeholders	Internal				First-Order			Second-Order			Product Life Cycle						
		Designers	Builders	Participants	Suppliers	System Providers	User	Adversaries	System Supporters	Customers	Competitors	Investors	Concept	Preliminary	Detail Design	Production	Deployment	Disposal
Other	Taxpayers								X								0.25	0.10
	Students						X										0.25	
	Professors						X										0.25	0.10
	Teachers						X										0.25	0.10
	Administrators							X									0.25	0.10
	Employees						X										0.25	0.10
	Parents							X									0.25	
	Families of users								X								0.25	
	Churches										X						0.25	
	Civic Organizations										X						0.25	
	Servicemen						X										0.25	
	Ship buyers										X						0.25	
	Investors										X						0.25	0.10
	Families of civil service engineers										X						0.25	
	Families of shipyard workers									X							0.25	
	Communities										X						0.25	

Table 33. Initial Classification of Stakeholders and Their Impact on System Lifecycle Stages, (4 of 4): Other

Stakeholder Category	Potential Stakeholders	Stakeholder Worth Matrix	Stakeholder # 1	Stakeholder # 2	Stakeholder # 3	Stakeholder # 4	Stakeholder # 5	Stakeholder # 6	Stakeholder # 7	Stakeholder # 8	Stakeholder # 9	Stakeholder # 10	Stakeholder # 11	Stakeholder # 12	Stakeholder # 13	Stakeholder # 14	Stakeholder # 15	Stakeholder # 16	Stakeholder # 17	Stakeholder # 18	Stakeholder # 19	Stakeholder # 20	Stakeholder # 21	Stakeholder # 22	Stakeholder # 23	Stakeholder # 24	Stakeholder # 25	Stakeholder # 26	Stakeholder # 27	
Academia	All colleges and universities that offer accredited undergraduate engineering degrees in the US	Stakeholder # 1	4	4	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	All colleges and universities that offer accredited graduate engineering degrees in the US	Stakeholder # 2		4		1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	All public and private secondary educational school systems in the US	Stakeholder # 3				1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	All technical colleges and universities that offer associate engineering degrees in the US	Stakeholder # 4					4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	All colleges and universities that offer specialty naval related degrees in the US	Stakeholder # 5						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	University of South Alabama	Stakeholder # 6							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	Old Dominion University Research Foundation	Stakeholder # 7									1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	University of Wisconsin-Marquette	Stakeholder # 8										1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	Jackson County School System (Mississippi)	Stakeholder # 9											1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	George County School System (Mississippi)	Stakeholder # 10												1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	Harrison County School System (Mississippi)	Stakeholder # 11													1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	Mobile County School System (Alabama)	Stakeholder # 12														1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	Jefferson Parish School System (Louisiana)	Stakeholder # 13															1	1	1	1	1	1	1	1	1	1	1	1	1	
	Naval Postgraduate School	Stakeholder # 14																1	1	1	1	1	1	1	1	1	1	1	1	
	Virgina Tech	Stakeholder # 15																	1	1	1	1	1	1	1	1	1	1	1	
	Texas A&M	Stakeholder # 16																		1	1	1	1	1	1	1	1	1	1	
	University of Maryland	Stakeholder # 17																			1	1	1	1	1	1	1	1	1	
	Stephens Institute	Stakeholder # 18																				1	1	1	1	1	1	1	1	
	Jackson State University	Stakeholder # 19																					1	1	1	1	1	1	1	
	Mississippi State University	Stakeholder # 20																						1	1	1	1	1	1	
	Ohio University	Stakeholder # 21																							1	1	1	1	1	
	University of Illinois	Stakeholder # 22																								1	1	1	1	
	University of Southern Mississippi	Stakeholder # 23																									1	1	1	
	University of Mississippi	Stakeholder # 24																										1	1	
	Pennsylvania State University	Stakeholder # 25																											1	1
	University of Delaware	Stakeholder # 26																												1
	University of New Orleans	Stakeholder # 27																												1

Table 34. Determination of Stakeholder Worth, (1 of 10): Academia to Academia

Stakeholder Category	Potential Stakeholders	Stakeholder Worth Matrix	Industry																															
Academia	All colleges and universities that offer accredited undergraduate engineering degrees in the US	Stakeholder # 1	1		1	4	4						4	1	9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
	All colleges and universities that offer accredited graduate engineering degrees in the US	Stakeholder # 2	1		1	4	4						4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
	All public and private secondary educational school systems in the US	Stakeholder # 3																																
	All technical colleges and universities that offer associate engineering degrees in the US	Stakeholder # 4																																
	All colleges and universities that offer specialty naval related degrees in the US	Stakeholder # 5																																
	University of South Alabama	Stakeholder # 6				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Old Dominion University Research Foundation	Stakeholder # 7				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	University of Wisconsin-Marquette	Stakeholder # 8				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Jackson County School System (Mississippi)	Stakeholder # 9				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	George County School System (Mississippi)	Stakeholder # 10				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Harrison County School System (Mississippi)	Stakeholder # 11				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mobile County School System (Alabama)	Stakeholder # 12				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Jefferson Parish School System (Louisiana)	Stakeholder # 13				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Naval Postgraduate School	Stakeholder # 14				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Virginia Tech	Stakeholder # 15				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Texas A&M	Stakeholder # 16				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	University of Maryland	Stakeholder # 17				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Stephens Institute	Stakeholder # 18				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Jackson State University	Stakeholder # 19				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mississippi State University	Stakeholder # 20				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Ohio University	Stakeholder # 21				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	University of Illinois	Stakeholder # 22				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	University of Southern Mississippi	Stakeholder # 23				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	University of Mississippi	Stakeholder # 24				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Pennsylvania State University	Stakeholder # 25				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	University of Delaware	Stakeholder # 26				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	University of New Orleans	Stakeholder # 27				1	4	4					4	1	9		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 35. Determination of Stakeholder Worth, (2 of 10): Academia to Industry

Stakeholder Category	Potential Stakeholders	Stakeholder Worth Matrix	Government																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
Academia	All colleges and universities that offer accredited undergraduate engineering degrees in the US	Stakeholder # 1	1	4	1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														

Table 36. Determination of Stakeholder Worth, (3 of 10): Academia to Government







Stakeholder Category	Potential Stakeholders	Stakeholder Worth Matrix	Industry																											
Industry	INCOSE - International Council On System Engineering	Stakeholder # 28																												
	ISO - International Organization for Standardization	Stakeholder # 29																												
	IEC - International Engineering Consortium	Stakeholder # 30																												
	IEEE - Institute of Electrical and Electronics Engineers	Stakeholder # 31																												
	ASNE - American Society of Naval Engineers	Stakeholder # 32																												
	SNAME - The Society of Naval Architects & Marine Engineers	Stakeholder # 33																												
	AIAA - American Institute of Aeronautics and Astronautics	Stakeholder # 34																												
	NASA - National Aeronautics & Space Administration	Stakeholder # 35																												
	ANSI - American National Standards Institute	Stakeholder # 36																												
	Electronic Industries Alliance	Stakeholder # 37																												
	All US shipyards	Stakeholder # 38																												
	US shipyard management	Stakeholder # 39																												
	Recruiting agencies	Stakeholder # 40																												
	All DoD contractors	Stakeholder # 41																												
	American Bureau of Shipping	Stakeholder # 42																												
	All shipyard contractors	Stakeholder # 43																												
	ASME - American Society of Mechanical Engineers	Stakeholder # 44																												
	Center for Innovation In Ship Design	Stakeholder # 45																												
	ASCE - American Society of Civil Engineers	Stakeholder # 46																												
	General Dynamics shipyards	Stakeholder # 47																												
	Bender Shipbuilding and Repair	Stakeholder # 48																												
	Bollinger Shipyards	Stakeholder # 49																												
	Northrop Grumman Shipbuilding-Gulf Coast	Stakeholder # 50																												
	Genoa Design International	Stakeholder # 51																												
	Gibbs & Cox, Murray & Associates	Stakeholder # 52																												
	ShipConstructor Software	Stakeholder # 53																												
	Art Anderson Associates	Stakeholder # 54																												
	Software Developers (Shipbuilding Tools)	Stakeholder # 55																												
	Northrop Grumman Newport News	Stakeholder # 56																												
	Colonna's Shipyard	Stakeholder # 57																												
	American Shipbuilding Association	Stakeholder # 58																												

Table 38. Determination of Stakeholder Worth, (5 of 10): Industry to Industry

Stakeholder Category	Potential Stakeholders	Stakeholder Worth Matrix	Government																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
			Stakeholder # 59	Stakeholder # 60	Stakeholder # 61	Stakeholder # 62	Stakeholder # 63	Stakeholder # 64	Stakeholder # 65	Stakeholder # 66	Stakeholder # 67	Stakeholder # 68	Stakeholder # 69	Stakeholder # 70	Stakeholder # 71	Stakeholder # 72	Stakeholder # 73	Stakeholder # 74	Stakeholder # 75	Stakeholder # 76	Stakeholder # 77	Stakeholder # 78	Stakeholder # 79	Stakeholder # 80	Stakeholder # 81	Stakeholder # 82	Stakeholder # 83	Stakeholder # 84	Stakeholder # 85	Stakeholder # 86	Stakeholder # 87	Stakeholder # 88	Stakeholder # 89	Stakeholder # 90	Stakeholder # 91	Stakeholder # 92	Stakeholder # 93	Stakeholder # 94	Stakeholder # 95	Stakeholder # 96	Stakeholder # 97	Stakeholder # 98	Stakeholder # 99	Stakeholder # 100	Stakeholder # 101	Stakeholder # 102	Stakeholder # 103	Stakeholder # 104	Stakeholder # 105	Stakeholder # 106	Stakeholder # 107	Stakeholder # 108	Stakeholder # 109	Stakeholder # 110	Stakeholder # 111	Stakeholder # 112	Stakeholder # 113	Stakeholder # 114	Stakeholder # 115	Stakeholder # 116	Stakeholder # 117	Stakeholder # 118																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
Industry	INCOSE - International Council On System Engineering	Stakeholder # 28																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				</

Stakeholder Category	Potential Stakeholders	Stakeholder Worth Matrix	Other										
Industry	INCOSE - International Council On System Engineering	Stakeholder # 28											
	ISO - International Organization for Standardization	Stakeholder # 29											
	IEC - International Engineering Consortium	Stakeholder # 30											
	IEEE - Institute of Electrical and Electronics	Stakeholder # 31											
	ASNE - American Society of Naval Engineers	Stakeholder # 32											
	SNAME - The Society of Naval Architects & Marine Engineers	Stakeholder # 33											
	AIAA - American Institute of Aeronautics and	Stakeholder # 34											
	NASA - National Aeronautics & Space Administration	Stakeholder # 35											
	ANSI - American National Standards Institute	Stakeholder # 36											
	Electronic Industries Alliance	Stakeholder # 37											
	All US shipyards	Stakeholder # 38	4	1	1								
	US shipyard management	Stakeholder # 39	4	1	1	4							
	Recruiting agencies	Stakeholder # 40	1	1	1	1							
	All DoD contractors	Stakeholder # 41	1	1	1	1							
	American Bureau of Shipping	Stakeholder # 42	4	1	1	4							
	All shipyard contractors	Stakeholder # 43	1	1	1	1							
	ASME - American Society of Mechanical Engineers	Stakeholder # 44	1	1	1	1							
	Center for Innovation In Ship Design	Stakeholder # 45	1	1	1	1							
	ASCE - American Society of Civil Engineers	Stakeholder # 46	1	1	1	1							
	General Dynamics shipyards	Stakeholder # 47	1	1	1	1							
	Bender Shipbuilding and Repair	Stakeholder # 48	1	1	1	1					1	1	1
	Bollinger Shipyards	Stakeholder # 49	1	1	1	1					1	1	1
	Northrop Grumman Shipbuilding-Gulf Coast	Stakeholder # 50	4	1	1	4					1	1	1
	Genoa Design International	Stakeholder # 51	1	1	1	1							
	Gibbs & Cox, Murray & Associates	Stakeholder # 52	1	1	1	1							
	ShipConstructor Software	Stakeholder # 53	1	1	1	1							
	Art Anderson Associates	Stakeholder # 54	1	1	1	1							
	Software Developers (Shipbuilding Tools)	Stakeholder # 55	1	1	1	1							
	Northrop Grumman Newport News	Stakeholder # 56	4	1	1	4					1	1	1
	Colonna's Shipyard	Stakeholder # 57	1	1	1	1							
	American Shipbuilding Association	Stakeholder # 58	4	1	1	4							

Table 40. Determination of Stakeholder Worth, (7 of 10): Industry to Other

Stakeholder Category	Potential Stakeholders	Stakeholder Worth Matrix	Government
Government	Local city government entities	Stakeholder # 59	Stakeholder # 118
	PEO Program Executive Office all associated	1	Stakeholder # 117
	PMS all associated groups	9 4	Stakeholder # 116
	Stakeholder # 61	9 4	Stakeholder # 115
	PMS all associated groups	9 4	Stakeholder # 114
	ESD - Electric Ship Office	4	Stakeholder # 113
	NSRP - National Shipbuilding Research Program	9 1 4 9 1	Stakeholder # 112
	Local state government entities	9 1 4 9 1	Stakeholder # 111
	Stakeholder # 64	9 1 4 9 1	Stakeholder # 110
	DEPARTMENT OF THE NAVY	1 4 9 1	Stakeholder # 109
	Stakeholder # 65	1 4 9 1	Stakeholder # 108
	Dod all associated groups	4 1	Stakeholder # 107
	Stakeholder # 66	4 1	Stakeholder # 106
	Congress	Stakeholder # 67	Stakeholder # 105
	NAVSEA all associated groups	Stakeholder # 68	Stakeholder # 104
	USMC all associated groups	Stakeholder # 69	Stakeholder # 103
	Army all associated groups	Stakeholder # 70	Stakeholder # 102
	Air Force all associated groups	Stakeholder # 71	Stakeholder # 101
	DAU - Defense Acquisition University	Stakeholder # 72	Stakeholder # 100
	Department of Defense Architecture Framework	Stakeholder # 73	Stakeholder # 99
	Department of Energy	Stakeholder # 74	Stakeholder # 98
	NAVAL AIR SYSTEMS COMMAND	Stakeholder # 75	Stakeholder # 97
	SPACE AND NAVAL WARFARE SYSTEMS COMMAND	Stakeholder # 76	Stakeholder # 96
	NAVAL SUPPLY SYSTEMS COMMAND	Stakeholder # 77	Stakeholder # 95
	PAK - Federal Acquisition Regulation	Stakeholder # 78	Stakeholder # 94
	Inter-Agency Logistics Command Management	Stakeholder # 79	Stakeholder # 93
	Naval Air Warfare Center Weapons Division	Stakeholder # 80	Stakeholder # 92
	Office of the Chief of Naval Operations	Stakeholder # 81	Stakeholder # 91
	Office of the Secretary of Defense	Stakeholder # 82	Stakeholder # 90
	Defense System Management College	Stakeholder # 83	Stakeholder # 89
	NSWC	Stakeholder # 84	Stakeholder # 88
	Stakeholder # 85	Stakeholder # 85	Stakeholder # 87
	Stakeholder # 86	Stakeholder # 86	Stakeholder # 86
	Stakeholder # 87	Stakeholder # 87	Stakeholder # 85
	Stakeholder # 88	Stakeholder # 88	Stakeholder # 84
	Stakeholder # 89	Stakeholder # 89	Stakeholder # 83
	Federally Funded Research and Development Center	Stakeholder # 90	Stakeholder # 82
	Joint Forces Command	Stakeholder # 91	Stakeholder # 81
	National Security Agency	Stakeholder # 92	Stakeholder # 80
	Strategic Command	Stakeholder # 93	Stakeholder # 79
	Environmental Protection Agency	Stakeholder # 94	Stakeholder # 78
	General Accounting Office	Stakeholder # 95	Stakeholder # 77
	National Academy of Public Administration	Stakeholder # 96	Stakeholder # 76
	National Academy of Sciences	Stakeholder # 97	Stakeholder # 75
	National Research Council	Stakeholder # 98	Stakeholder # 74
	National Science Board	Stakeholder # 99	Stakeholder # 73
	National Science Foundation	Stakeholder # 100	Stakeholder # 72
	Office of Personnel Management	Stakeholder # 101	Stakeholder # 71
	U.S. Department of Education	Stakeholder # 102	Stakeholder # 70
	CONSWC	Stakeholder # 103	Stakeholder # 69
	POTUS	Stakeholder # 104	Stakeholder # 68
	Government Labs	Stakeholder # 105	Stakeholder # 67
	U.S. Coast Guard (associated departments and leadership)	Stakeholder # 106	Stakeholder # 66
	Dept. of Homeland Security	Stakeholder # 107	Stakeholder # 65
	Defense Acquisition Review Board	Stakeholder # 108	Stakeholder # 64
	ESRDC	Stakeholder # 109	Stakeholder # 63
	ONR	Stakeholder # 110	Stakeholder # 62
	Jackson County government entities (Mississippi)	Stakeholder # 111	Stakeholder # 61
	George County government entities (Mississippi)	Stakeholder # 112	Stakeholder # 60
	Harrison County government entities (Mississippi)	Stakeholder # 113	Stakeholder # 59
	Mobile County government entities (Alabama)	Stakeholder # 114	
	Jefferson Parish government entities (Louisiana)	Stakeholder # 115	
	Louisiana state government entities	Stakeholder # 116	
	Mississippi state government entities	Stakeholder # 117	



Stakeholder Category	Potential Stakeholders	Stakeholder Worth Matrix	Other																
			Stakeholder # 119	Stakeholder # 120	Stakeholder # 121	Stakeholder # 122	Stakeholder # 123	Stakeholder # 124	Stakeholder # 125	Stakeholder # 126	Stakeholder # 127	Stakeholder # 128	Stakeholder # 129	Stakeholder # 130	Stakeholder # 131	Stakeholder # 132	Stakeholder # 133	Stakeholder # 134	
Government	Local city government entities	Stakeholder # 59	1	1	1	1	1	1	1	1	1	1						1	
	PEO (Program Executive Office) all associated	Stakeholder # 60		1	4	1	1	4					1	1					
	PMS all associated groups	Stakeholder # 61		1	4	1	1	4					1	1					
	ESO - Electric Ship Office	Stakeholder # 62		1	4	1	1	4					1	1					
	NSRP - National Shipbuilding Research Program	Stakeholder # 63		1	4	1	1	4					1	1					
	Local state government entities	Stakeholder # 64	1	1	1	1	1	1	1	1	1	1						1	
	DEPARTMENT OF THE NAVY	Stakeholder # 65		1	4	1	1	4					1	1					
	DoD all associated groups	Stakeholder # 66		1	1	1	1	1					1	1					
	Congress	Stakeholder # 67		1	1	1	1	1	1					1	1				
	NAVSEA all associated groups	Stakeholder # 68		1	4	1	1	4						1	1				
	USMC all associated groups	Stakeholder # 69		1	1	1	1	1						1	1				
	Army all associated groups	Stakeholder # 70																	
	Air Force all associated groups	Stakeholder # 71																	
	DAU - Defense Acquisition University	Stakeholder # 72																	
	Department of Defense Architecture Framework	Stakeholder # 73																	
	Department of Energy	Stakeholder # 74																	
	NAVAL AIR SYSTEMS COMMAND	Stakeholder # 75		1	4	1	1	4						1	1				
	SPACE AND NAVAL WARFARE SYSTEMS COMMAND	Stakeholder # 76		1	4	1	1	4							1	1			
	NAVAL SUPPLY SYSTEMS COMMAND	Stakeholder # 77		1	1	1	1	1							1	1			
	FAR - Federal Acquisition Regulation	Stakeholder # 78																	
	Naval Aviation Logistics Command Management Information System	Stakeholder # 79		1	1	1	1	1	1						1	1			
	Naval Air Warfare Center Weapons Division	Stakeholder # 80		1	1	1	1	1							1	1			
	Office of the Chief of Naval Operations	Stakeholder # 81		1	1	1	1	1	1						1	1			
	Office of the Secretary of Defense	Stakeholder # 82		1	1	1	1	1	1						1	1			
	Defense System Management College	Stakeholder # 83																	
	NSWC	Stakeholder # 84																	
	CIA - Central Intelligence Agency	Stakeholder # 85																	
	DIA - Defense Intelligence Agency	Stakeholder # 86																	
	Defense Information Systems Agency	Stakeholder # 87																	
	Defense Science Board	Stakeholder # 88		1	1	1	1	1	1					1	1	1			
	Defense Threat Reduction Agency	Stakeholder # 89																	
	Federally Funded Research and Development Center	Stakeholder # 90		1	1	1	1	1	1					1	1	1			
	Joint Forces Command	Stakeholder # 91																	
	National Security Agency	Stakeholder # 92																	
	Strategic Command	Stakeholder # 93																	
	Environmental Protection Agency	Stakeholder # 94																	
	General Accounting Office	Stakeholder # 95																	
	National Academy of Public Administration	Stakeholder # 96																	
	National Academy of Sciences	Stakeholder # 97		1	1	1	1	1	1					1	1	1			
	National Research Council	Stakeholder # 98		1	1	1	1	1	1					1	1	1			
	National Science Board	Stakeholder # 99		1	1	1	1	1	1					1	1	1			
	National Science Foundation	Stakeholder # 100		1	1	1	1	1	1					1	1	1			
	Office of Personnel Management	Stakeholder # 101																	
	U.S. Department of Education	Stakeholder # 102		1	1	1	1	1	1					1	1	1			
	CDNSWC	Stakeholder # 103																	
	POTUS	Stakeholder # 104																	
	Government Labs	Stakeholder # 105																	
	U.S. Coast Guard (associated departments and leadership)	Stakeholder # 106		1	1	1	1	1	1						1	1			
	Dept. of Homeland Security	Stakeholder # 107																	
	Defense Acquisition Review Board	Stakeholder # 108																	
	ESRDC	Stakeholder # 109																	
	ONR	Stakeholder # 110																	
	Jackson County government entities (Mississippi)	Stakeholder # 111		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
	George County government entities (Mississippi)	Stakeholder # 112		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
	Harrison County government entities (Mississippi)	Stakeholder # 113		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
	Mobile County government entities (Alabama)	Stakeholder # 114		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
	Jefferson Parish government entities (Louisiana)	Stakeholder # 115		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
	Louisiana state government entities	Stakeholder # 116		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
	Mississippi state government entities	Stakeholder # 117		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
	Alabama state government entities	Stakeholder # 118		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1

Table 42. Determination of Stakeholder Worth, (9 of 10): Government to Other

Stakeholder Category	Potential Stakeholders	Stakeholder Worth Matrix	Other															
			Stakeholder # 119	Stakeholder # 120	Stakeholder # 121	Stakeholder # 122	Stakeholder # 123	Stakeholder # 124	Stakeholder # 125	Stakeholder # 126	Stakeholder # 127	Stakeholder # 128	Stakeholder # 129	Stakeholder # 130	Stakeholder # 131	Stakeholder # 132	Stakeholder # 133	Stakeholder # 134
Other	Taxpayers	Stakeholder # 119									1							1
	Students	Stakeholder # 120		4	4	1		1										
	Professors	Stakeholder # 121			4	1		1										
	Teachers	Stakeholder # 122				1		1										
	Administrators	Stakeholder # 123						1										
	Employees	Stakeholder # 124									1							1
	Parents	Stakeholder # 125									1							1
	Families of users	Stakeholder # 126																
	Churches	Stakeholder # 127									1							1
	Civic Organizations	Stakeholder # 128																1
	Servicemen	Stakeholder # 129																
	Ship buyers	Stakeholder # 130																
	Investors	Stakeholder # 131																
	Families of civil service engineers	Stakeholder # 132																
	Families of shipyard workers	Stakeholder # 133																
	Communities	Stakeholder # 134																

Table 43. Determination of Stakeholder Worth, (10 of 10): Other to Other

Stakeholder Category	Potential Stakeholders	Importance			Influence			Total Stakeholder Worth	Stakeholder Classification		
		Number of Interactions	Worth of Interactions	Total Level of Importance	Relationship Type	Duration in Life Cycle	Total Level of Influence		Primary?	Secondary?	Tertiary?
Academia	All colleges and universities that offer accredited undergraduate engineering degrees in the US	59	94	5546	1	0.25	0.25	1386.5	No	No	Yes
	All colleges and universities that offer accredited graduate engineering degrees in the US	59	94	5546	1	0.25	0.25	1386.5	No	No	Yes
	All public and private secondary educational school systems in the US	26	35	910	1	0.25	0.25	227.5	No	No	Yes
	All technical colleges and universities that offer associate engineering degrees in the US	26	29	754	1	0.25	0.25	188.5	No	No	Yes
	All colleges and universities that offer specialty naval related degrees in the US	26	52	1352	1	0.25	0.25	338	No	No	Yes
	University of South Alabama	58	97	5626	9	0.25	2.25	12658.5	No	No	Yes
	Old Dominion University Research Foundation	58	97	5626	4	0.50	2	11252	No	No	Yes
	University of Wisconsin-Marquette	39	78	3042	4	0.25	1	3042	No	No	Yes
	Jackson County School System (Mississippi)	39	70	2730	9	0.35	3.15	8599.5	No	No	Yes
	George County School System (Mississippi)	39	70	2730	9	0.35	3.15	8599.5	No	No	Yes
	Harrison County School System (Mississippi)	39	70	2730	9	0.35	3.15	8599.5	No	No	Yes
	Mobile County School System (Alabama)	39	70	2730	9	0.35	3.15	8599.5	No	No	Yes
	Jefferson Parish School System (Louisiana)	39	70	2730	9	0.35	3.15	8599.5	No	No	Yes
	Naval Postgraduate School	39	70	2730	9	2.85	25.65	70024.5	Yes	No	No
	Virginia Tech	39	70	2730	4	0.25	1	2730	No	No	Yes
	Texas A&M	39	70	2730	4	0.25	1	2730	No	No	Yes
	University of Maryland	39	70	2730	4	0.25	1	2730	No	No	Yes
	Stephens Institute	39	70	2730	4	0.25	1	2730	No	No	Yes
	Jackson State University	39	70	2730	9	0.50	4.5	12285	No	No	Yes
	Mississippi State University	39	70	2730	9	0.50	4.5	12285	No	No	Yes
	Ohio University	39	70	2730	4	0.25	1	2730	No	No	Yes
	University of Illinois	39	70	2730	4	0.25	1	2730	No	No	Yes
	University of Southern Mississippi	39	70	2730	9	0.50	4.5	12285	No	No	Yes
	University of Mississippi	39	70	2730	9	0.50	4.5	12285	No	No	Yes
	Pennsylvania State University	39	70	2730	4	0.25	1	2730	No	No	Yes
	University of Delaware	39	70	2730	4	0.25	1	2730	No	No	Yes
	University of New Orleans	39	70	2730	9	0.50	4.5	12285	No	No	Yes

Table 44. Determination of Stakeholder Importance, Influence, and Final Classification (1 of 4): Academia

Stakeholder Category	Potential Stakeholders	Importance			Influence		Total Stakeholder Worth	Stakeholder Classification			
		Number of Interactions	Worth of Interactions	Total Level of Importance	Relationship Type	Duration in Life Cycle		Total Level of Influence	Primary?	Secondary?	Tertiary?
Industry	INCOSE - International Council On System Engineering	2	2	4	4	0.60	2.4	9.6	No	No	Yes
	ISO - International Organization for Standardization	0	0	0	1	0.25	0.25	0	No	No	Yes
	IEC - International Engineering Consortium	0	0	0	1	0.25	0.25	0	No	No	Yes
	IEEE - Institute of Electrical and Electronics Engineers	36	36	1296	4	0.25	1	1296	No	No	Yes
	ASNE - American Society of Naval Engineers	36	125	4500	4	0.60	2.4	10800	No	No	Yes
	SNAME - The Society of Naval Architects & Marine Engineers	36	125	4500	4	0.60	2.4	10800	No	No	Yes
	AIAA - American Institute of Aeronautics and Astronautics	0	0	0	1	0.25	0.25	0	No	No	Yes
	NASA - National Aeronautics & Space Administration	0	0	0	1	0.25	0.25	0	No	No	Yes
	ANSI - American National Standards Institute	0	0	0	1	0.25	0.25	0	No	No	Yes
	Electronic Industries Alliance	0	0	0	1	0.25	0.25	0	No	No	Yes
	All US shipyards	69	187	12903	1	0.35	0.35	4516.05	No	No	Yes
	US shipyard management	66	112	7392	9	1.10	9.9	73180.8	Yes	No	No
	Recruiting agencies	66	264	17424	4	0.25	1	17424	No	Yes	No
	All DoD contractors	45	45	2025	4	0.25	1	2025	No	No	Yes
	American Bureau of Shipping	69	119	8211	4	0.60	2.4	19706.4	No	Yes	No
	All shipyard contractors	45	48	2160	4	0.25	1	2160	No	No	Yes
	ASME - American Society of Mechanical Engineers	69	72	4968	4	0.25	1	4968	No	No	Yes
	Center for Innovation In Ship Design	42	66	2772	9	0.60	5.4	14968.8	No	No	Yes
	ASCE - American Society of Civil Engineers	69	72	4968	4	0.25	1	4968	No	No	Yes
	General Dynamics shipyards	66	81	5346	1	0.35	0.35	1871.1	No	No	Yes
	Bender Shipbuilding and Repair	78	93	7254	1	0.35	0.35	2538.9	No	No	Yes
	Bollinger Shipyards	78	93	7254	1	0.35	0.35	2538.9	No	No	Yes
	Northrop Grumman Shipbuilding-Gulf Coast	78	379	29562	9	2.85	25.65	758265.3	Yes	No	No
	Genoa Design International	66	81	5346	1	0.25	0.25	1336.5	No	No	Yes
	Gibbs & Cox, Murray & Associates	66	81	5346	1	0.25	0.25	1336.5	No	No	Yes
	ShipConstructor Software	66	81	5346	1	0.25	0.25	1336.5	No	No	Yes
	Art Anderson Associates	66	81	5346	1	0.25	0.25	1336.5	No	No	Yes
	Software Developers (Shipbuilding Tools)	66	66	4356	1	0.50	0.5	2178	No	No	Yes
	Northrop Grumman Newport News	70	152	10640	9	0.60	5.4	57456	No	Yes	No
	Colonna's Shipyard	66	78	5148	1	0.25	0.25	1287	No	No	Yes
	American Shipbuilding Association	66	119	7854	9	1.10	9.9	77754.6	Yes	No	No

Table 45. Determination of Stakeholder Importance, Influence, and Final Classification (2 of 4): Industry



Stakeholder Category	Potential Stakeholders	Importance			Influence			Total Stakeholder Worth	Stakeholder Classification		
		Number of Interactions	Worth of Interactions	Total Level of Importance	Relationship Type	Duration in Life Cycle	Total Level of Influence		Primary?	Secondary?	Tertiary?
Government	Local city government entities	57	66	3762	4	0.25	1	3762	No	No	Yes
	PEO (Program Executive Office) all associated groups	59	192	11328	9	0.60	5.4	61171.2	No	Yes	No
	PMS all associated groups	59	192	11328	9	0.60	5.4	61171.2	No	Yes	No
	ESO - Electric Ship Office	59	141	8319	9	0.25	2.25	18717.75	No	Yes	No
	NSRP - National Shipbuilding Research Program	84	198	16632	9	1.85	16.65	276922.8	Yes	No	No
	Local state government entities	56	56	3136	4	0.25	1	3136	No	No	Yes
	DEPARTMENT OF THE NAVY	86	255	21930	9	1.10	9.9	217107	Yes	No	No
	DoD all associated groups	59	65	3835	4	0.35	1.4	5369	No	No	Yes
	Congress	62	89	5518	4	0.35	1.4	7725.2	No	No	Yes
	NAVSEA all associated groups	62	209	12958	9	1.85	16.65	215750.7	Yes	No	No
	USMC all associated groups	59	59	3481	1	0.25	0.25	870.25	No	No	Yes
	Army all associated groups	0	0	0	1	0.25	0.25	0	No	No	Yes
	Air Force all associated groups	0	0	0	1	0.25	0.25	0	No	No	Yes
	DAU - Defense Acquisition University	11	11	121	1	0.35	0.35	42.35	No	No	Yes
	Department of Defense Architecture Framework	0	0	0	1	0.25	0.25	0	No	No	Yes
	Department of Energy	0	0	0	1	0.25	0.25	0	No	No	Yes
	NAVAL AIR SYSTEMS COMMAND	37	87	3219	1	0.25	0.25	804.75	No	No	Yes
	SPACE AND NAVAL WARFARE SYSTEMS COMMAND	37	87	3219	1	0.25	0.25	804.75	No	No	Yes
	NAVAL SUPPLY SYSTEMS COMMAND	37	61	2257	1	0.25	0.25	564.25	No	No	Yes
	FAR - Federal Acquisition Regulation	0	0	0	1	0.25	0.25	0	No	No	Yes
	Naval Aviation Logistics Command Management Information System	26	26	676	1	0.25	0.25	169	No	No	Yes
	Naval Air Warfare Center Weapons Division	38	62	2356	1	0.25	0.25	589	No	No	Yes
	Office of the Chief of Naval Operations	60	108	6480	4	1.10	4.4	28512	No	Yes	No
	Office of the Secretary of Defense	63	111	6993	4	0.25	1	6993	No	No	Yes
	Defense System Management College	0	0	0	1	0.25	0.25	0	No	No	Yes
	NSWC	0	0	0	1	0.25	0.25	0	No	No	Yes
	CIA - Central Intelligence Agency	0	0	0	1	0.25	0.25	0	No	No	Yes
	DIA - Defense Intelligence Agency	0	0	0	1	0.25	0.25	0	No	No	Yes
	Defense Information Systems Agency	0	0	0	1	0.25	0.25	0	No	No	Yes
	Defense Science Board	34	34	1156	1	0.35	0.35	404.6	No	No	Yes
	Defense Threat Reduction Agency	16	16	256	1	0.25	0.25	64	No	No	Yes
	Federally Funded Research and Development Center	34	34	1156	1	0.25	0.25	289	No	No	Yes
	Joint Forces Command	26	26	676	1	0.25	0.25	169	No	No	Yes
	National Security Agency	26	26	676	1	0.35	0.35	236.6	No	No	Yes
	Strategic Command	26	26	676	1	0.35	0.35	236.6	No	No	Yes
	Environmental Protection Agency	0	0	0	1	0.25	0.25	0	No	No	Yes
	General Accounting Office	21	21	441	1	0.60	0.6	264.6	No	No	Yes
	National Academy of Public Administration	0	0	0	1	0.25	0.25	0	No	No	Yes
	National Academy of Sciences	82	82	6724	1	0.60	0.6	4034.4	No	No	Yes
	National Research Council	58	58	3364	1	0.60	0.6	2018.4	No	No	Yes
	National Science Board	82	82	6724	1	0.35	0.35	2353.4	No	No	Yes
	National Science Foundation	58	58	3364	1	0.60	0.6	2018.4	No	No	Yes
	Office of Personnel Management	0	0	0	1	0.25	0.25	0	No	No	Yes
	U.S. Department of Education	82	154	12628	1	0.60	0.6	7576.8	No	No	Yes
	CDNSWC	0	0	0	1	0.25	0.25	0	No	No	Yes
	POTUS	0	0	0	1	0.25	0.25	0	No	No	Yes
	Government Labs	0	0	0	4	0.25	1	0	No	No	Yes
	U.S. Coast Guard (associated departments and leadership)	36	36	1296	4	0.35	1.4	1814.4	No	No	Yes
	Dept. of Homeland Security	27	27	729	4	0.35	1.4	1020.6	No	No	Yes
	Defense Acquisition Review Board	0	0	0	1	0.35	0.35	0	No	No	Yes
	ESRDC	28	52	1456	4	0.35	1.4	2038.4	No	No	Yes
	ONR	28	98	2744	9	0.35	3.15	8643.6	No	No	Yes
	Jackson County government entities (Mississippi)	24	32	768	4	0.35	1.4	1075.2	No	No	Yes
	George County government entities (Mississippi)	24	32	768	4	0.35	1.4	1075.2	No	No	Yes
	Harrison County government entities (Mississippi)	24	32	768	4	0.35	1.4	1075.2	No	No	Yes
	Mobile County government entities (Alabama)	24	32	768	4	0.35	1.4	1075.2	No	No	Yes
	Jefferson Parish government entities (Louisiana)	24	32	768	4	0.35	1.4	1075.2	No	No	Yes
	Louisiana state government entities	24	32	768	4	0.35	1.4	1075.2	No	No	Yes
	Mississippi state government entities	24	32	768	4	0.35	1.4	1075.2	No	No	Yes
	Alabama state government entities	24	32	768	4	0.35	1.4	1075.2	No	No	Yes

Table 46. Determination of Stakeholder Importance, Influence, and Final Classification (3 of 4): Government

Stakeholder Category	Potential Stakeholders				Importance			Influence			Total Stakeholder Worth	Stakeholder Classification		
					Number of Interactions	Worth of Interactions	Total Level of Importance	Relationship Type	Duration in Life Cycle	Total Level of Influence		Primary?	Secondary?	Tertiary?
Other	Taxpayers	12	12	144	1	0.35	0.35	50.4	No	No	Yes			
	Students	83	179	14857	4	0.25	1	14857	No	No	Yes			
	Professors	83	113	9379	4	0.35	1.4	13130.6	No	No	Yes			
	Teachers	83	89	7387	4	0.35	1.4	10341.8	No	No	Yes			
	Administrators	38	38	1444	4	0.35	1.4	2021.6	No	No	Yes			
	Employees	81	123	9963	4	0.35	1.4	13948.2	No	No	Yes			
	Parents	16	16	256	4	0.25	1	256	No	No	Yes			
	Families of users	10	10	100	1	0.25	0.25	25	No	No	Yes			
	Churches	12	12	144	1	0.25	0.25	36	No	No	Yes			
	Civic Organizations	22	22	484	1	0.25	0.25	121	No	No	Yes			
	Servicemen	32	32	1024	4	0.25	1	1024	No	No	Yes			
	Ship buyers	28	28	784	1	0.25	0.25	196	No	No	Yes			
	Investors	4	4	16	1	0.35	0.35	5.6	No	No	Yes			
	Families of civil service engineers	8	8	64	1	0.25	0.25	16	No	No	Yes			
	Families of shipyard workers	12	12	144	1	0.25	0.25	36	No	No	Yes			
	Communities	19	19	361	1	0.25	0.25	90.25	No	No	Yes			

Table 47. Determination of Stakeholder Importance, Influence, and Final Classification (4 of 4): Other

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## APPENDIX E

This Appendix presents the compiled list of stakeholder needs as discussed in Chapter III. This data is presented in Table 48, which gives results of the identification of stakeholder needs based on the classification of primary and secondary stakeholders discussed in Chapter III. The list consists of 74 stakeholder needs determined through investigation and research of relevant stakeholder documentation.

Stakeholder Need	Source
Matching the most experience people to shipbuilding programs with highest risk	(Sullivan, Stiller, Architzel, Hilarides, & Goddard, 2007)
Strong systems engineering skills among the U.S. Navy, U.S. Coast Guard, and shipbuilder teams are necessary to balance valid, yet competing demands	(Teel, 2007)
There is an urgency to preserve the knowledge infrastructure in naval engineering	(Chrysostomidis, Bernitsas, & Burke, 2000)
US world leadership in naval engineering through research, recruitment and education must be ensured in order to maintain an adequate base of talent, and sustain critical infrastructure for research and experimentation	(Chrysostomidis, et al., 2000)
Government, academia, and industry must collaborate to meet each other's needs to be able to attract high quality engineering students in adequate numbers	(Chrysostomidis, et al., 2000)
People who have the knowledge, skills and experience to perform innovative design and engineering	(Chrysostomidis, et al., 2000)
An industry that employs these people and allows this innovative knowledge to be applied in the ships	(Chrysostomidis, et al., 2000)
Recommendations to establish long term support that will provide for the introduction of innovative technology in naval ships	(Chrysostomidis, et al., 2000)
The design of complex marine systems and design for manufacturing	(Chrysostomidis, et al., 2000)
Need for a solid national knowledge infrastructure	(Chrysostomidis, et al., 2000)
Revolutionize the state of the art in ship analysis and design and to bring the participants, industry, government and academia closer together in perspective and time for innovation	(Chrysostomidis, et al., 2000)
An educational system which provides engineers and scientist with a basic understanding of design and materials and systems thinking needed to design ships	(Chrysostomidis, et al., 2000)
Support of naval engineering faculty through fellowships, research projects directed at Navy objectives	(Chrysostomidis, et al., 2000)
Schools must become more involved with the US shipbuilding industry	(Chrysostomidis, et al., 2000)
Synthesis skills gained through experience	(Chrysostomidis, et al., 2000)
Students want:	(Chrysostomidis, et al., 2000)
o fields general enough so they can finds jobs in many different industries	(Chrysostomidis, et al., 2000)
o fields that are high tech in the sense of use of computers, visualization, and robots	(Chrysostomidis, et al., 2000)
o fields which enable them to find jobs with high salaries upon graduation	(Chrysostomidis, et al., 2000)
o fields which are challenging	(Chrysostomidis, et al., 2000)
Academia wants to:	(Chrysostomidis, et al., 2000)
o offer all curricula (BS, MS, and Ph.D.)	(Chrysostomidis, et al., 2000)
o maintain and upgrade expensive and unique experimental facilities	(Chrysostomidis, et al., 2000)

Stakeholder Need	Source
o continually evolve all curricula due to the changing nature of engineering practices and education	(Chrysostomidis, et al., 2000)
o quickly implement research products in design at the graduate and undergraduate level	(Chrysostomidis, et al., 2000)
o compete with other departments (i.e. computer science, medicine, etc.) for students and consequently new faculty positions and college resources	(Chrysostomidis, et al., 2000)
o educate young engineers for a 30 to 40 year career	(Chrysostomidis, et al., 2000)
o attract research funding from government and industry	(Chrysostomidis, et al., 2000)
o maintain certain level of research funding or risk losing faculty positions	(Chrysostomidis, et al., 2000)
o provide a mechanism and funding for spontaneous re-education of faculty	(Chrysostomidis, et al., 2000)
o maintain comprehensive curricula at all levels by teaching their courses and hiring adjunct faculty to teach	(Chrysostomidis, et al., 2000)
o Government wants to:	(Chrysostomidis, et al., 2000)
o maintain basic and applied research capability in naval engineering and related fields to provide innovation for future naval vessels	(Chrysostomidis, et al., 2000)
o ensure that US universities produce adequate number of high quality engineers in naval engineering and related fields	(Chrysostomidis, et al., 2000)
o initiate programs oriented toward bridging the gap between industry and academia in the long and short term	(Chrysostomidis, et al., 2000)
o Initiative that involves industry in a substantive way and creates an environment of exciting and challenging innovative research	(Chrysostomidis, et al., 2000)
o Significance of educating young engineers in overall design of ships	(Chrysostomidis, et al., 2000)
o Strong involvement of academia from conceptual design to implementation	(Chrysostomidis, et al., 2000)
o Establish awards for study and research leading to advance degrees in naval engineering and related fields	(Chrysostomidis, et al., 2000)
o Establish apprenticeships between government, academia and industry	(Chrysostomidis, et al., 2000)
o Academia to survey shipbuilding industry and government to determine their needs related to naval engineering and related fields	(Chrysostomidis, et al., 2000)
o Promote faculty increase for naval engineering and related fields	(Chrysostomidis, et al., 2000)
o Program and funding stability and increased volume is critical to achieving greater labor efficiency	(Toner, 2005)
o The American shipbuilding industry must demonstrate that it is a healthy and robust environment to attract and retain the next generation of shipbuilders	(Toner, 2005)
o Achieving learning efficiencies in a low rate production environment	(Toner, 2005)
o Attract a new generation of engineers into shipbuilding	(Toner, 2005)
o Preserve production capabilities	(Toner, 2005)
o Sustain critical shipbuilding skills and capabilities	(Toner, 2005)
o Develop an enterprise wide human capital strategy	(Keane, 2007)
o Protect the Government's technical authority	(Keane, 2007)
o Manage careers to fill the pipeline of future leaders	(Keane, 2007)
o Need to generate a new workforce of knowledge workers	(Keane, 2007)
o Need engineers with the ability to think globally & enterprise wide, with systems perspective, excellent communication and interpersonal skills	(Keane, 2007)
o Need to provide accelerated knowledge transfer from older engineers to younger engineers	(Keane, 2007)

Stakeholder Need	Source
o Create a new model of integrated research, education and training that is exciting, provides engineering depth, and focuses on technical leadership, through team-building exercises, leadership training and professional work experience	(Keane, 2007)
o Enhance academia's understanding of Navy needs	(Genalis, 2006)
o Stimulate research with more near term impact to Navy	(Genalis, 2006)
o Stimulate flow of talent in naval engineering (graduate students, faculty)	(Genalis, 2006)
o Sustain a robust research expertise	(Genalis, 2006)
o Provide an adequate pipeline of new researchers, engineers, and faculty	(Genalis, 2006)
o Entice older workers to stay on the job later	(Brandon, 2008)
o Getting older workers to teach younger workers vital skills	(Brandon, 2008)
o Transfer of knowledge to others behind them	(Brandon, 2008)
o Coach and mentor others	(Brandon, 2008)
o Challenging work assignments to get older workers to stay	(Brandon, 2008)
o Develop strategies encouraging high school students to pursue careers in science and engineering	(Department of the Navy, 1982)
o Afford young the opportunity to explore careers coupled with positive role model experiences	(Department of the Navy, 1982)
o All eligible students afforded the opportunity to participate	(Department of the Navy, 1982)
o Challenging and developmental work assignments	(Department of the Navy, 1982)
o Experience in career exploration and guidance is provided	(Department of the Navy, 1982)
o Encourage and support careers in science and technology	(Department of the Navy, 1982)
o Stimulate among high school students broader interest in careers in science and engineering	(Department of the Navy, 1982)
o Establish individual working relationships between students and active researchers	(Department of the Navy, 1982)
o Strengthen the nation's effort to recruit and sustain careers in science and engineering	(Department of the Navy, 1982)
o Increasing apprentice worth to the research community through retention	(Department of the Navy, 1982)
o Encourage students to stay in school	(Department of the Navy, 1982)
o Provide technical assistance, training, materials, and guidance for educators and experiential learning coordinators	(Department of the Navy, 1982)

Table 48. Compiled List of Human Capital Shipbuilding Industry Specific Stakeholder Needs

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## **APPENDIX F**

This appendix presents the Overall Measure of Effectiveness (OMOE) Model developed for Chapter V. Table 49 and Figure 58 present the results of the Analytic Hierarchy Process (AHP) pair-wise comparison of the ten top-level stakeholder requirements. The weightings shown were applied in a Quality Function Deployment (QFD) flow down, as shown in Figure 59 through Figure 62, to derive weightings for the design form elements of the HCM architecture. The OMOE calculation based on these weightings is presented in Figure 63 through Figure 65. The scoring of each design form element was performed according the attribute scoring table shown in Table 50. All comparison rating and scoring shown is subjective, based on the judgment of the authors acting as stakeholders of the proposed HCM architecture



Top Level System Requirements																		
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase Awareness
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Promote NA&ME Curriculum Devel.
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Attract, Develop, Retain Human Capital
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Knowledge Transfer
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Knowledge Capture
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Promote Shipublding Innovations
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Encourage NA&ME as Career Choice
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Compete for Talent w/other professions
Maintain Knowledge and Skills Base	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase Worth of Technical Work Force

Table 49. Initial Pair-Wise Comparison of Stakeholder HCM Architecture Requirements Using Notional Requirements Scoring (After Whitcomb, 2008a).

**Prioritization of Stakeholder Requirements via Pair-Wise Comparison**

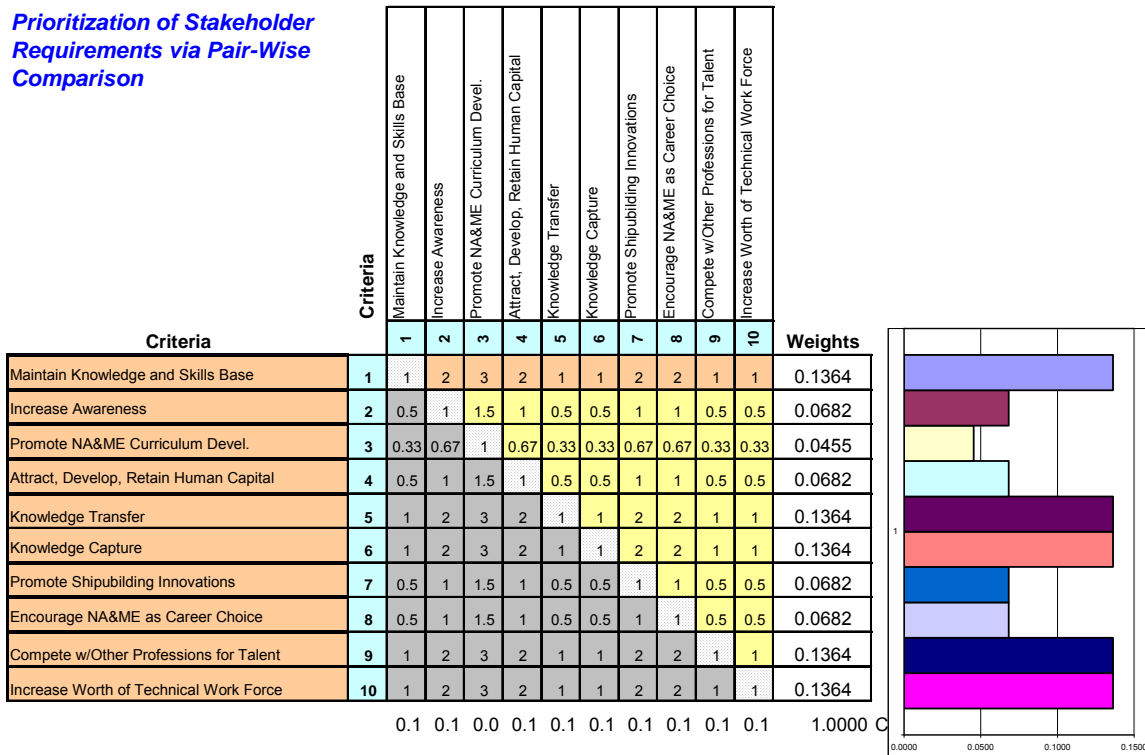


Figure 58. Pair-Wise Comparison Matrix for HCM Architecture Requirements Using Notional Requirements Scoring (After Whitcomb, 2008a).

**Proposed HCM Architecture:  
Quality Function Deployment First  
Level:**  
Stakeholder Requirements (Whats) to  
Design Characteristics (Hows)

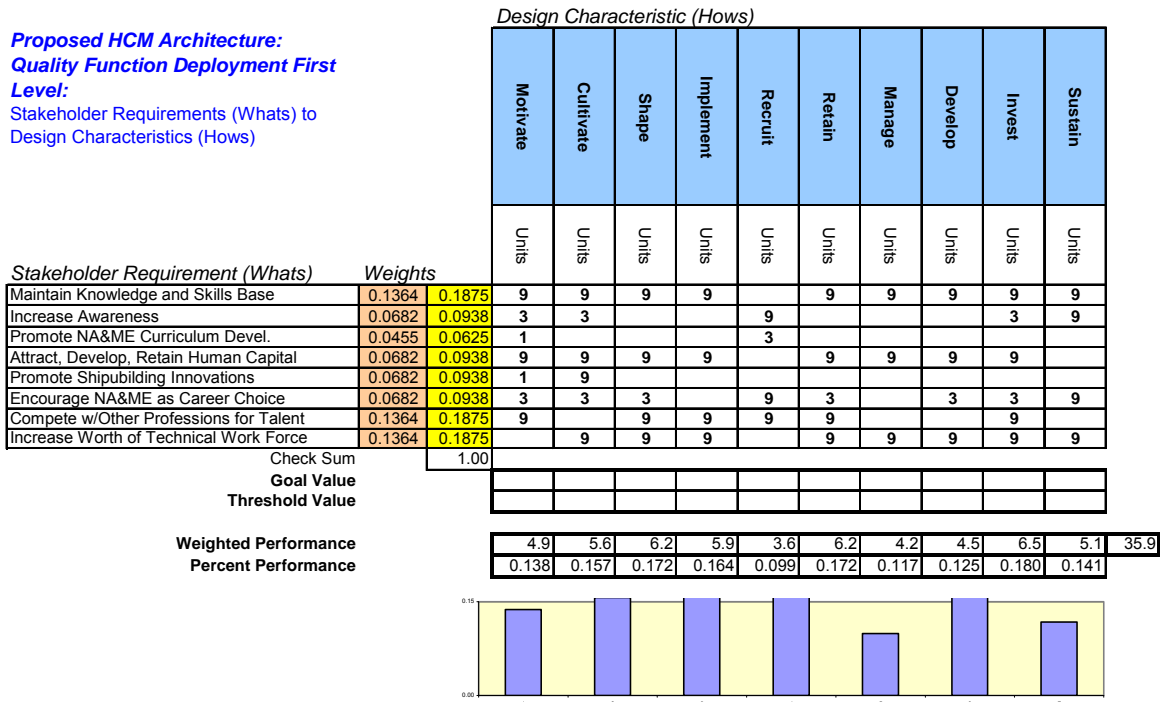


Figure 59. First Level QFD Matrix for Comparison of Top-Level Stakeholder Requirements to HCM Architecture Design Attributes (After Whitcomb, 2008b).

**Proposed HCM Architecture:  
Quality Function Deployment  
Second Level:**  
Design Characteristics (Whats) to  
Functions (Hows)

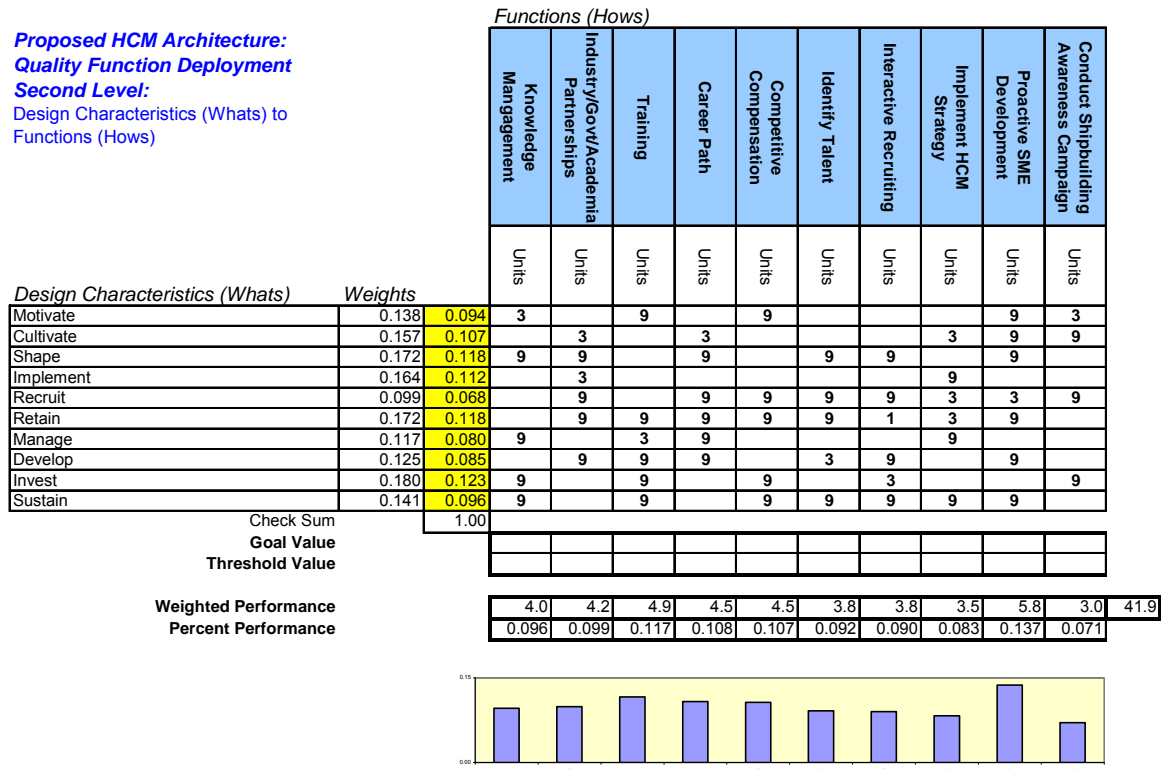


Figure 60. Second Level QFD Matrix for Comparison of HCM Architecture Design Attributes to Top Level HCM Architecture Functions (After Whitcomb, 2008b).

**Proposed HCM Architecture:  
Quality Function Deployment**  
**Third Level:**  
Functions (Whats) to Form (Hows)

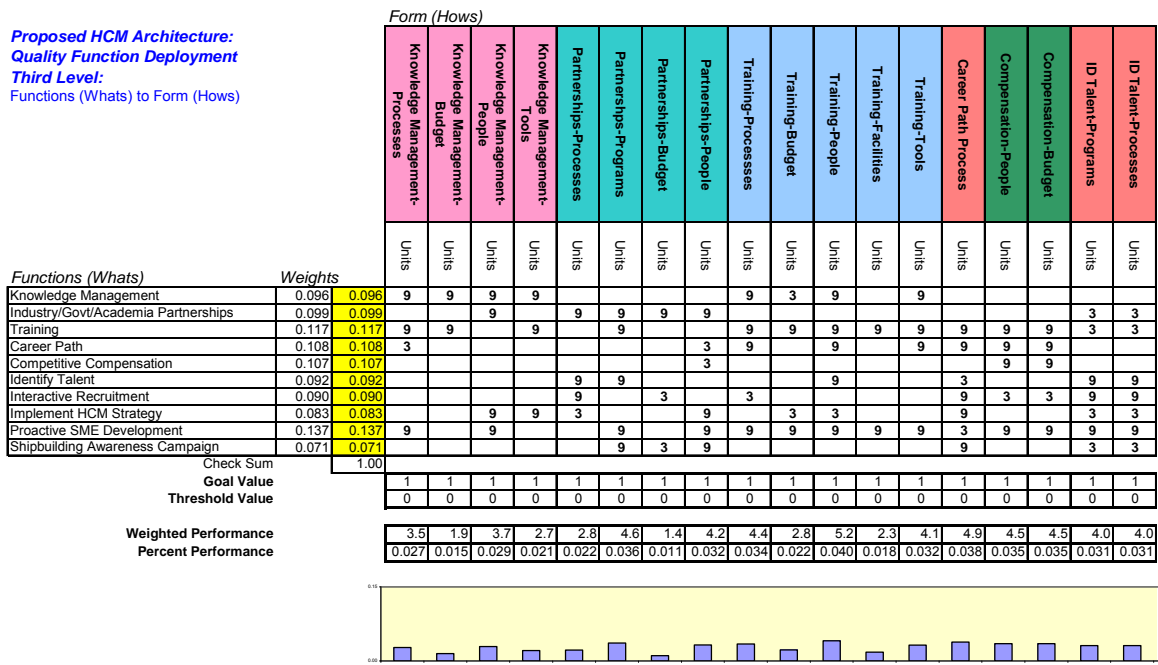


Figure 61. Third Level QFD Matrix for Comparison of HCM Architecture Design Attributes to Top Level HCM Architecture Functions, Part 1 (After Whitcomb, 2008b).

**Proposed HCM Architecture:**  
**Quality Function Deployment**  
**Third Level:**  
 Functions (Whats) to Form (Hows)

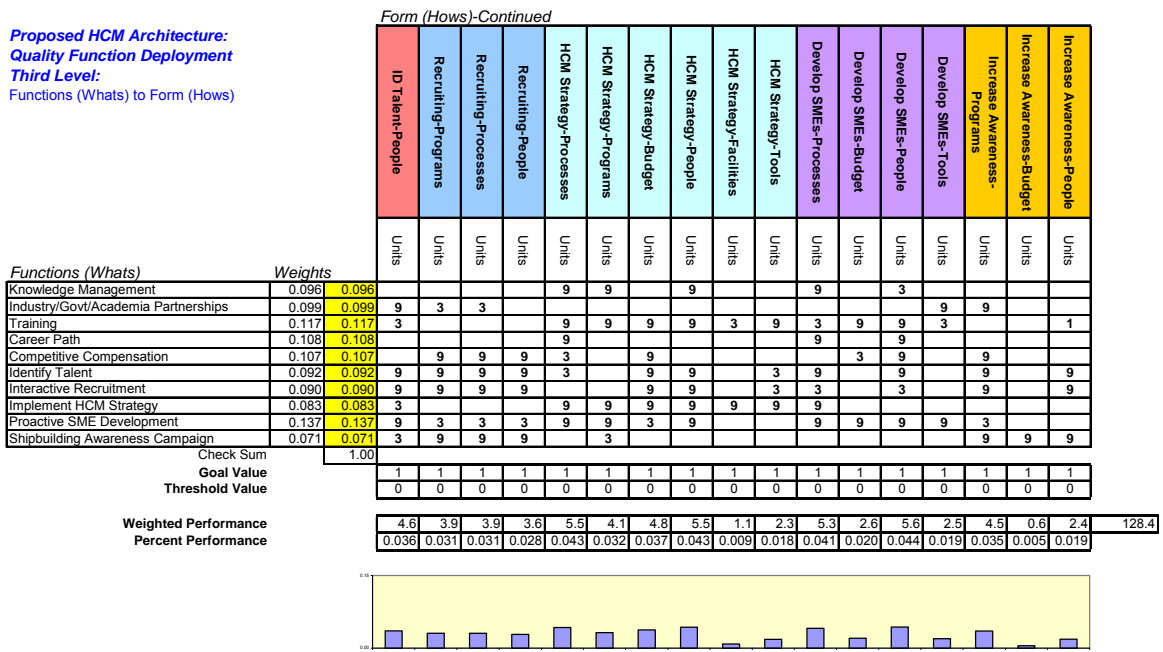


Figure 62. Third Level QFD Matrix for Comparison of HCM Architecture Design Attributes to Top Level HCM Architecture Functions, Part 2 (After Whitcomb, 2008b).

<b>Attribute Scoring Table</b>	Low	Medium	High
Knowledge Management-Programs	0	0.5	1.0
Knowledge Management-Budget	0	0.6	1.0
Knowledge Management-People	0	0.7	1.0
Knowledge Management-Tools	0	0.5	1.0
Awareness-People	0	0.7	1.0
Awareness-Budget	0	0.6	1.0
Awareness-Programs	0	0.5	1.0
Partnerships-Processes	0	0.8	1.0
Partnerships-Programs	0	0.5	1.0
Partnerships-Budget	0	0.6	1.0
Partnerships-People	0	0.7	1.0
Training-Processes	0	0.8	1.0
Training-Budget	0	0.6	1.0
Training-People	0	0.7	1.0
Training-Facilities	0	0.5	1.0
Training-Tools	0	0.5	1.0
Recruiting-Program	0	0.5	1.0
Recruiting-Process	0	0.8	1.0
Recruiting-People	0	0.7	1.0
HCM Strategy-Process	0	0.8	1.0
HCM Strategy-Program	0	0.5	1.0
HCM Strategy-Budget	0	0.6	1.0
HCM Strategy-People	0	0.7	1.0
HCM Strategy-Facilities	0	0.5	1.0
HCM Strategy-Tools	0	0.5	1.0
Career Path Process	0	0.8	1.0
ID Talent-Program	0	0.5	1.0
ID Talent-Process	0	0.8	1.0
ID Talent-People	0	0.7	1.0
Compensation-People	0	0.7	1.0
Compensation-Budget	0	0.6	1.0
Develop SMEs-Process	0	0.8	1.0
Develop SMEs-People	0	0.7	1.0
Develop SMEs-Budget	0	0.6	1.0
Develop SMEs-Tools	0	0.5	1.0

Table 50. Attribute Scoring Table for HCM Architecture Design Form Elements (After Whitcomb, 2008b).

OMOE Model For Proposed HCM Architecture

MOE Weight	MOE Criteria Name	MOP Weight	MOP Attribute Name	MOP Threshold	MOP Goal	Attained	Remarks
LEGEND:							
MOE Key		MOP Key					
	Computed weight		Computed weight				
	Weight obtained from QFD 1		Weight obtained from QFD 3				
	Weight input from assessment		Weight input from assessment				

Overall MOE <sub>i</sub>
0.629

MOE Weight	MOE Criteria Name	MOP Weight	MOP Attribute Name	MOP Threshold	MOP Goal	Attained	Remarks
		0.027	Knowledge Management-Programs	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
		0.027	0.5				
		0.015	Knowledge Management-Budget	0	1	0.6	Level L=0; Level M=0.60; Level H=1.0
		0.015	0.6				
0.1875	Maintain Knowledge and Skills Base	0.029	Knowledge Management-People	0	1	0.7	Level L=0; Level M=0.70; Level H=1.0
0.1364		0.029	0.7				
		0.021	Knowledge Management-Tools	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
		0.021	0.5				
		0.035	Awareness-People	0	1	0.7	Level L=0; Level M=0.70; Level H=1.0
		0.035	0.7				
0.0938	Increase Awareness	0.005	Awareness-Budget	0	1	0.6	Level L=0; Level M=0.60; Level H=1.0
0.0682		0.005	0.6				
		0.019	Awareness-Programs	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
		0.019	0.5				
		0.022	Partnerships-Processes	0	1	0.8	Level L=0; Level M=0.80; Level H=1.0
		0.022	0.8				
		0.036	Partnerships-Programs	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
		0.036	0.5				
0.0625	Promote NA&ME Curriculum Development	0.011	Partnerships-Budget	0	1	0.6	Level L=0; Level M=0.60; Level H=1.0
0.0455		0.011	0.6				
		0.032	Partnerships-People	0	1	0.7	Level L=0; Level M=0.70; Level H=1.0
		0.032	0.7				

Figure 63. HCM Architecture OMOE Model, 1 of 3 (After Whitcomb, 2008b).

OMOE Model For Proposed HCM Architecture

MOE Weight	MOE Criteria Name	MOP Weight	MOP Attribute Name	MOP Threshold	MOP Goal	Attained	Remarks
LEGEND:							
MOE Key		MOP Key					
	Computed weight		Computed weight				
	Weight obtained from QFD 1		Weight obtained from QFD 3				
	Weight input from assessment		Weight input from assessment				
Overall MOE <sub>i</sub> 0.629							
MOE Weight	MOE Criteria Name	MOP Weight	MOP Attribute Name	MOP Threshold	MOP Goal	Attained	Remarks
		0.034	Training-Processes	0	1	0.8	Level L=0; Level M=0.80; Level H=1.0
		0.034	0.8				
		0.022	Training-Budget	0	1	0.6	Level L=0; Level M=0.60; Level H=1.0
		0.022	0.6				
		0.040	Training-People	0	1	0.7	Level L=0; Level M=0.70; Level H=1.0
		0.040	0.7				
		0.018	Training-Facilities	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
		0.018	0.5				
0.0938	Attract, Develop, & Retain Human Capital	0.032	Training-Tools	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
0.0682		0.032	0.5				
		0.031	Recruiting-Program	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
		0.031	0.5				
		0.031	Recruiting-Process	0	1	0.8	Level L=0; Level M=0.80; Level H=1.0
		0.031	0.8				
		0.028	Recruiting-People	0	1	0.7	Level L=0; Level M=0.70; Level H=1.0
		0.028	0.7				
		0.043	HCM Strategy-Process	0	1	0.8	Level L=0; Level M=0.80; Level H=1.0
		0.043	0.8				
		0.032	HCM Strategy-Program	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
		0.032	0.5				
0.0938	Promote Shipubilding Innovations	0.037	HCM Strategy-Budget	0	1	0.6	Level L=0; Level M=0.60; Level H=1.0
0.0682		0.037	0.6				
		0.043	HCM Strategy-People	0	1	0.7	Level L=0; Level M=0.70; Level H=1.0
		0.043	0.7				
		0.009	HCM Strategy-Facilities	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
		0.009	0.5				
		0.018	HCM Strategy-Tools	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
		0.018	0.5				

Figure 64. HCM Architecture OMOE Model, 2 of 3 (After Whitcomb, 2008b).



OMOE Model For Proposed HCM Architecture

MOE Weight	MOE Criteria Name	MOP Weight	MOP Attribute Name	MOP Threshold	MOP Goal	Attained	Remarks
LEGEND:							
MOE Key		MOP Key					
	Computed weight		Computed weight				
	Weight obtained from QFD 1		Weight obtained from QFD 3				
	Weight input from assessment		Weight input from assessment				

Overall MOE<sub>i</sub>

0.629

MOE Weight	MOE Criteria Name	MOP Weight	MOP Attribute Name	MOP Threshold	MOP Goal	Attained	Remarks
		0.038	Career Path Process	0	1	0.8	Level L=0; Level M=0.80; Level H=1.0
		0.038	0.8				
	1.02						
0.0938	Encourage NA&ME as Career Choice	0.031	ID Talent-Program	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
0.0682		0.031	0.5				
		0.031	ID Talent-Process	0	1	0.8	Level L=0; Level M=0.80; Level H=1.0
		0.031	0.8				
		0.036	ID Talent-People	0	1	0.7	Level L=0; Level M=0.70; Level H=1.0
		0.036	0.7				
		0.035	Compensation-People	0	1	0.7	Level L=0; Level M=0.70; Level H=1.0
		0.035	0.7				
	0.24						
0.1875	Compete w/Other Professions for Talent	0.035	Compensation-Budget	0	1	0.6	Level L=0; Level M=0.60; Level H=1.0
0.1364		0.035	0.6				
		0.041	Develop SMEs-Process	0	1	0.8	Level L=0; Level M=0.80; Level H=1.0
		0.041	0.8				
	0.44						
0.1875	Increase Worth of Technical Work Force	0.020	Develop SMEs-People	0	1	0.7	Level L=0; Level M=0.70; Level H=1.0
0.1364		0.020	0.7				
		0.044	Develop SMEs-Budget	0	1	0.6	Level L=0; Level M=0.60; Level H=1.0
		0.044	0.6				
		0.019	Develop SMEs-Tools	0	1	0.5	Level L=0; Level M=0.50; Level H=1.0
		0.019	0.5				

1.0000 Check

0.7273 Weighting Sum

1.000 Check

1.000 Weighting Sum

Figure 65. HCM Architecture OMOE Model, 3 of 3 (After Whitcomb, 2008b).

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